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ECONOMIC COMMISSION FOR AFRICA

Industry and Human Settlements Division

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TECHNICAL PUBLICATION OF THE IMPROVEMENT OF THE AGRICULTURAL EQUIPMENT MAINTENANCE CAPACITY OF AN IDENTIFIED NATIONAL, SUBREGIONAL OR REGIONAL INSTITUTION FOR MAINTENANCE OF AGRICULTURAL EQUIPMENT

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1. INTRODUCTION

1.1. Trends in the Use of Agricultural Equipment in Africa

1.1.1 Background*

Africa is a continent made of countries the majority of which belong to th low income category. As per World Report 1988 of the World Bank, of the total 44 low income countries 30 belong to Africa.

Africa with 166.4 million hectars accounts for 12.12 per cent of the world's total arable land. In terms of population, its share is 11.74 per cent. About sixty five per cent of the economically active population earn their livelihood from agriculture. While the economically active population in agriculture has grown by 39.4 per cent over the last 15 years, the total arable land has increased by a mere 7.8 per cent during the same period. In other words, the land has to support more people per unit of area and the ability to recover more land for agricultural purpose has not been growing at comparable rate. Furthermore, in terms of irrigated land, Africa's share is not only low at 4.8 per cent of the global total but registered a cumulative growth of 21.3 per cent against the world 31.8 per cent over the 15 year period. Though Africa cultivates over 12 per cent of the world's arable land, food production has not been able to meet the continent's needs. Cereal production dominates African agriculture, but with a total annual average of 77.5 million tons, it accounts for only 4.3 per cent of the total world production.

Particularly worrying is the low productivity of agriculture. There are obviously a number of factors that suppress the productivity of farming in Africa among which the application of low level of technologies features most prominent.

In spite of its significant share of total cultural land, the continent deploys only 2.04 per cent and 1.25 per cent of the world's total tractors and harvestors respectively. Over the last fifteen years the tractor flee in Africa increased by 11.7 per cent only against the world's 15.6 per cent. This implies that not only does Africa use low level technology in agriculture but also the trend in change is growing at much lower rate than that of the rest of the world.

1.1.2 Choice of Technology

Available levels of technology in agricultural equipment usage are generall classified into the following three categories :

Hand tool technology : Hand tool technology was the first attempt in the development of agricultural equipment. It depends fully on human effort for its source of power. It is the lowest mode of production and has a low energy conversion rate as well as low productivity.

Animal powered technology : This level of technology is based on animals as source of power. It employs oxen and/or horses to pull a range of farm implements for land cultivation, seed application and harvesting. The choice of use of animal technology and of implements to go with it depends on the availability, type and size of animal, and type of soils to be negotiated. Animal power has enabled farmers to increase labour productivity.

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*Figures in this section are based on FAO Production Year Book, 1988.

However, its ability to increase land productivity depends on other technological inputs. Animal powered technology is the second important technology level employed in Africa. Animal traction is a new introduction in most parts of Africa. Where animal traction has been a tradition,it has not changed both in its application or in the associated implements used. Animal traction, because of its low initial and operational costs, seems to be a better choice for African states at the initial stage of mechanization.

Mechanizal powered technology : Mechanical powered technology has developed significantly over the years. It uses engine driven equipment for cultivation, seeding, input application, harvesting and post-harvest processing. The level of technology can vary from mechanization of the critical operations to nearly all farm activities. Powered technology has helped the world to increase both labour productivity and land productvity many times. With the exception of South Africa and few countries North of the Sahara, use of mechanical powered technology is limited. All in all less than 20 per cent of the cultivated land is mechanized in Africa.

1.1.3 Africa's choice

The choice of any particular level of technology and/or combination thereof depends on many physical and socio-economic conditions. Africa with all its development constraints has serious difficulties in adapting any particular level of technology. This is manifested by **lack of policies and strategies for agricultural mechanization. A few African countries have such policies and strategies.**

Immediately after independence, most African countries with the aim of increasing agricultural production have jumped on the idea of deploying powered technology in their agriculture, particularly encouraged by the earlier success of white settlers' farms. However, due to the increasing cost of powered machinery (few countries have capability to manufacture), in particular the foreign exchange component, the inadequacy or absence of management system and skills in handling powered machinery, and high operating costs (fuel and parts), African nations are re-considering the use of powered technology.

Several African countries are providing tractor service to the peasant farmer through tractor hire schemes. These schemes, in most cases, are unsuccessful. Most of the equipment was either made out of use in a very short time had such low productivity rate that the schemes could not be operated economically. Frustrated by their earlier experience and the inability to finance powered machinery such countries are giving preference to animal powered technology. A lot of effort is being expended by most African countries to popularize the use of animal traction as well as develop improved implements. This trend is being adversely affected by poor animal health,low traction power of the African draught animal and difficult soil conditions.

1.2 Africa's Priority Programme for Economic Recovery (APPER) and United Nations Programme of Action for African Economic Recovery and Development (UNPAAERD) Focus on Agricultural Equipment

The United Nations General Assembly, in recognition of Africa's grave economic and social crisis, at its eighth Plennay Meeting of the thirteenth special session held in June 1986 has adopted a Programme of Action for African Economic Recovery and Development, 1986-1990, welcoming Africa's Priority Programme for Economic Recovery mapped out by the Assembly of Head of States and Government of the Organization of African Unity at its twenty first ordinary session held in Addis Ababa from 18 to 20 July 1985.

Within the framework of this programme, agricultural development has been given considerable emphasis by alloting it US$57.4 billion which is 44.8 per cent of the programme cost. The need to revitalize agricultural development throughout the programme period by specific actions, both at the national and subregional levels, within this action programme and the aspect of agricultural equipment have been given due emphasis. The action programme specifically identifies the need to, among others :

" - raising substantially the level of investment in agriculture;
- increased food production;
- restoring, protecting and developing arable land and rendering it more productive;
- establishment of remunerative producer pricing policies, establishment and strengthening of incentive schemes, eliminating pricing policies that have tended to discourage production and providing effective agriculture credit programmes;
- development of livestock and livestock products through the utilization of agricultural by-products, improved management and attention to animal diseases;
- development of mechanization and the use of modern farm and processing machinery; increased use of fertilizers, improved seeds and pesticides;
- improving and expanding the storage capacity, distribution and the marketing system;
- development of agricultural research and extension through the creation of a network of agronomical research stations and extension for the design and diffusion of appropriate agricultural technologies;
- placing at the disposal of small farmers necessary inputs for increased yields; better utilization and improvement in management of water resources and the establishment of low-cost irrigation schemes;
- establishment of reafforestation, drought and desertification control programmes, including firewood schemes; and improvement of agricultural implement maintenance capacity;
- establishment of assistance programmes for small farmers, especially women food producers and rural youth;
- improvement of the distribution of agricultural products".

Furthermore, the action programme points out that the success of the programme in agricultural development will depend on the parallel development of the agricultural support sectors, including :

" - rehabilitation and development of agro-related industries;
- development of transport and communications;
- trade and finance".
-

Among the measures to be taken in the support sectors, include :

" - development of industries for production of agricultural tools and equipment;
- establishment of engineering capacity for the production of spare parts and components".

The implementation of the action programme implies the parallel development of Africa's capability to manage its economy and resources, such as the improvement of public management systems, institutions and practices, particularly the improvement of the performance of public enterprises and maintenance capability and capacity of agricultural equipment.

1.3 Objectives and scope of the study

Among the many factors hampering the adoption of improved technological package in agricultural mechanization is Africa's inability to manage powered equipment properly. While most tractors employed in developed countries have an average working life of over eight years and an average annual productive hours of over 1,000,in Africa most tractors are out of use in less than four years and have average annual productive hours of less than 300. A tractor hire scheme in Zambia which acquired 450 tractors had only 32 tractors in working condition in six years time and productive hours for operational tractors was as low as 150 hours per year. In Ethiopia, of the 2,526 tractors in the state farms only 1,028 tractors (40.7 per cent) are only operational currently. The primary reasons for such low serviceability and productivity of agricultural equipment are :

- inappropriate selection of equipment;
- lack of recognition of the roll of maintenance in ensuring higher productivity and serviceability;
- lack of facilities for performing proper maintenance;
- inadequate and untimely delivery of parts;
- inadequacy or absence of skilled manpower, both for operation and maintenance, and
- absence of proper maintenance policies, systems and practices.

In recognition of the importance of maintenance of agricultural equipment in shaping the future development and use of higher technologies as well as in response to the call made in UN-PAAERD, the United Nations Economic Commission for Africa has undertaken this study with the following key objectives :

a) Bring to the attention of the African countries the institutional and conceptual issues of agricultural equipment maintenance;

b) Create awareness of the roll of maintenance in the successful implementation of a mechanization programme;

c) Identify and bring to the attention of the African public policy and strategy issues for the successful implementation of maintenance programmes; and

d) Suggest institutional frame-work and management systems required for the implementation of a maintenance improvement programme.

The scope of the study is intended to develop guidelines defining techniques in undertaking maintenance capability improvement programme for maintenance institutions, at national level, for both captive users and for those organized to provide services to others.

2. PRIORITY AGRICULTURAL EQUIPMENT

Equipment packages available for any particular or combination level of technology selected are many. Maintenance requirements of the various equipment packages also are as varied as the elements constituting the packages. The appropriateness of any particular maintenance system is dependent on the level of technology employed, the system of ownership and the location of the equipment relative to maintenance facilities. In view of this, it is found necessary to identify some of the priority agricultural equipment for the different levels of technologies.

2.1 Hand tool technology

Hand tool technology is generally employed or feasible only where individual farm size is less than two hectars. Hand tool technology in Africa is used by peasants who are found all over the country, away from basic infrastructures. The package of hand tools in use and likely to be used in Africa for key agricultural operations mainly consist of:

- Land preparation tools-axes, shovels, spades, digging hoes, pick-axes, etc.;
- Seed application tools-walking-stick planters, manual wheel seeders, manual seed drills;
- Post-seeding operation tools - hand cultivators, wheeled weeders, forked hoes, manual fertilizer drills, dusters, knap-sac sprayers, and
- Harvesting tools - machets, sickles.

2.2 Animal drawn technology

Animal drawn technology is generally employed and appropriate where individual farms are below five hectars. However, farms above five hectars are also feasible with animal traction but require the use of more than one team of draught power. Animal drawn technology is also used by peasants inhabiting rural areas where there is limited infrastructure.

Animal draught is accompanied by a series of implements to be drawn for different applications. Though it is possible to perform most operations with animal power in Africa, animal power is mostly used for land preparation work. This is partly due to lack of appropriate implements for other activities, low purchasing power of farmers and lack of awareness of the benefits of these implements.

Though several African countries have attempted limited research and development works as well as local production of improved animal drawn implements for operations other than land preparation, acceptability by farmers is slow and very low. One of the reasons for such low acceptability is that most of these implements are intended to help land productivity rather than labour productivity. A manual seed drill, for instance, requires more labour time than spreading by hand. Besides, the benefits of the use of such implements are not readily seen as the final output is the result of a number of other factors, such as the weather, pest infestation and harvest losses. Because of these factors, farmers have reservations on the benefits. On the other hand, a farmer can easily see the benefits accruing from use of farm implements that increase labour productivity.

The equipment packages which are used or likely to be used with animal drought consist of :

- Land preparation implements - ploughs (ard, Maresha, single furrow mouldboard plough), tool bar, disc-harrows, spike tooth harrows, land levelers;
- Seed application implements - row planter (single and multiple furrow), seed drills; and
- Post seeding implements - cultivators (tines, duck foots),

2.3 Mechanical powered technology

Mechanical powered technology is commonly used in farms of more than ten hectars, mostly in commercial and large-scale farms. Mechanical powered technology has a wide range of technology packages, ranging from power tillers and wind mills for pumping water to the sophisticated large tractors with trains of implements for multiple operations. The choice of the technology package depends on the size of the farm, the level of management and financial resources available for investment. In Africa, the choice of technology package is limited to basic equipment for critical operations. For African conditions and needs the following comprise priority equipment sequence of operation listed according to :

- Land preparation equipment - Tractors of 35-150 HP with three point linkage and power take off (PTO), land tillage implements such as sub-soilers, chisel ploughs, disc and reversable mouldboard ploughs, disc harrows (off-set, mounted ridgers;
- Seed application equipment - raw planters, seed-drills, direct drills and spreaders;
- Post-seeding equipment - cultivators (tine, duck foot), fertilizer spreaders, trailed sprayers, trailed dusters;
- Harvesting equipment - mowers, combine harvestors (self-propelled and trail), trailers, threshers, shellers;and
- Water supply and irrigation equipment - engine driven or electric driven centrefugal pumps, submersible pumps, sprinkler irrigation. systems.

3. MAJOR AREAS OF CONSTRAINTS TO MAINTENANCE

Whichever technology level is selected, the need to organize for delivery of proper maintenance is of extreme importance. The allocation of enormous resources to a given level of technology without provision for the maintenance component has led to catastrophic results. Organizing for maintenance is time consuming and requires the removal or minimization of many external and internal constraints. For the successful implementation of a maintenance system, the development of an action programme to minimize or remove these constraints need to be addressed. Some of the many constraints requiring the attention of the African countries are:

3.1 Policy issues

For the development and successful implementation of a maintenance programme, it is inevitable that needs have to be established. Maintenance needs can only be established when information on the level of mechanization and its long-term evolution is defined. To this end, policies and strategies on agricultural mechanizations need to be defined, both at the regional and national levels. With the exception of few countries in Africa, mechanization policies and long-term strategies do not exist. As a result of shift from one level of technology to anotehr and the haphazard nature of development of the use of agricultural equipment, no systematic development of maintenance capabilities could be made. It is noted that at some stage when tractorization was popular a net-work of dealer workshops and service stations were mushrooming, however most of these service workshops had to close down and trained technicians had to move to other sectors due to later shift to animal traction and dwindling imports.

Furthermore, not only is maintenance of agricultural equipment constrained by the absence of mechanization policy and long-term strategies, but there is also a total lack of policy on maintenance. There is lack of committed policies or constant practices as to who shall be responsible for the import and distribution and services of imported or locally manufactured equipment.

At the operational level, the options of maintenance systems are not known, even if known are not articulared or adhered to. For lack of defined guidelines (what level of maintenance to perform when, what maintenance to perform where, and what skill level and environmental conditions are required for the different tasks of maintenance) wrong maintenance practices are normal features. This leads to higher down-time of equipment, high maintenance cost and lower productivity. Furthermore, capability building for maintenance or effective utilization of facilities or resources through planned maintenance practices are unattainable. In order for improved maintenance to result, the following policy aspects ought to be formulated and enforced :

- The elaboration of the chosen level/levels of agricultural mechanization, its long-term evolution and systems of review in relation to production and maintenance;
- Policies for the promotion and coordination at the national level of the development, production and maintenance of agricultural equipment and implements; and
- Policies with regard to defining the modalities for participation and the areas of operation of the various institutions involved in the delivery of maintenance or support services.

The definition of overall policies will help the long-term development of maintenance. However, unless such policies are further strengthened by detailed policy in implementation, they will not achieve the purpose. Africa at present imports most of its needs. Whatever degree of capability has been achieved is heavily dependent on imported components, parts or raw materials. Quality of imported inputs and their designs vary from supplier to supplier with the result that maintenance needs do vary both in nature and frequency from machine to machine. As a result of market forces or other socio-political considerations, the types, makes and models models imported to a country are many and varied. With increasing number of makes and models of equipment, building maintenance capabilities is made difficult. The various types, makes and models require varied skill levels and provisioning of a wide range of spares. In addition to requiring huge resources, this is near impossible to satisfactorily organize.

As imported equipment is not designed taking into consideration African conditions, adaptability in most cases is questionable. From both Zambian and Ethiopian experiences it has been witnessed that parts and components working normally in the country of origin fail in Africa. This has led to very high demand for extensive maintenance and parts, which are not readily available in some cases. This is partly due to the absence of policy on import procedures, such as demanding the execution of testing and evaluation prior to import and lack of policy on standardization. The formulation and implementation of such policies on testing and evaluation are further restrained by lack of both know-how and absence of infrastructure. Formulation and adherence to standardization policy is not easily realizable, partly due to lack of accumulated knowledge on the performance of any specific model and the danger of creating monopoly market. It is also in some ways difficult to implement due to various restrictions imposed by sources of finance and also because of donor assisted projects which often require purchase from donor country only.

Whatever the constraints may be, formulating and enforcing standardization policies for a successful maintenance programme and adherence and commitment to standardization are important considerations. To this end, attempts should be made to minimize the number of makes and models of imported equipment, and fix the minimum number to be imported to be comensurate with available maintenance facilities. Testing and evaluation may be costly and time consuming but their merits in the long-run are warranted and, therefore, governments need to develop policy guidelines as well as assist the building of capabilities.

3.2 Institutional support

The development of maintenance capacity will hardly be achieved without adequate government support. Certain aspects of maintenance improvement programme require a more global and detailed analysis which demand a wide spectrum of skills. Further, the development of an effective maintenance programme requires significant amount of resources. The benefits of good maintenance practice are of long term nature and not directly observed. It requires institutional support which are lacking or inadequate in Africa. As a result, maintenance improvement programmes are constrained. Among the many institutional supports for better maintenance are:

3.2.1 Research and development

Research and development on maintenance is an important element for effective planning, designing systems and execution of maintenance. Research on maintenance is costly and time consuming. It deals with detailed investigation of frequently occurring maintenance problems on individual machines and the development of methods of minimizing such problems. It also means investigation on wrong designs, wrong applications, quality of materials and wrong maintenance practices and dissemination of the findings to end users. The complexity and extent of research in the field of maintenance makes it virtually impossible for operational units to attempt. Therefore, development of such capabilities (which are presently lacking) by governments is an important consideration.

3.2.2 Financial assistance

Maintenance requires the building of infrastructures. These consist of buildings to house maintenance, workshop equipment, specialized and general tools and adequate stock of spares. To build such facilities requires substantial resources. The rate of return on investment of maintenance facilities is low. Furthermore, most of the financial requirements are in foreign exchange which is scarce. While most financial institutions are ready to finance investment on new equipment they are reluctant to provide resources to build maintenance infrastructures. For lack of resources maintenance is being undertaken inside buildings which are not appropriate and poorly equipped.

The building up of inventory of spare parts ties capital and is associated with frequent needs of foreign exchange. Foreign exchange is not only required to replenish stocks but also to meet urgent needs. The present system of allocating foreign exchange does not differentiate between need of spares for agricultural equipment from others or urgent needs from replenshment for stock. Orders by direct remittance, cash against document, and revolving letter of credit are effective means for entertaining urgent needs. Presently, both suppliers and host governments require the processing of foreign exchange permit applications and opening of letter of credits for even the smallest orders. Such practices entail increased lead time (as much as nine months to a year before parts are received). This in turn has led most operators to resort to canibalization which if exercised frequently has disasterous results.

For maintenance to be effective there is need for support from and commitment of financial institutions to provide resources and facilitate faster means of their acquisition

3.2.3 Information system

Information on lives of machines, operating hours, maintenance costs and needs for spare parts ought to be accumulated for sharing experience in the identification of appropriate equipment as well as in developing improved maintenance systems. In the absence of any central organ for the accumulation and processing of such information, both the implementation of agricultural mechanization and maintenance improvement programmes would be difficult. Processed information(typical of African conditions) would facilitate the development of effective maintenance systems. African countries should consider the establishment of such information centers aimed at creating a means for exchange of African experiences.

3.3 Institutional frame-work and infrastructure

The creation of institutional frame-work and building infrastructure for maintenance as noted earlier requires substantial resources, clear and definite policy guidelines on mechanization and maintenance. As peasant agriculture dominales the African scene, delivery of maintenance and building of infrastructure is a complex matter. This is so, partly due to individual ownership of equipment and dispersed and rural location. Unless the institutional framework is clearly designed and infrastructures are built following the instititional framework, the introduction of maintenance system is made difficult.

Few African countries have mapped out such a frame-work or initiated building infrastructures. The absence of infrastructure is critical at all levels.

3.3.1 Central maintenance workshop

The useful life of agricultural equipment can be extended through systematic and well organized preventive maintenance schemes. Facilities for rebuilding or re-generation of components, parts and assemblies are required. The acquisition of new equipment is getting more expensive each day and the need to make the maximum use of equipment on hand is advisable. The few facilities that are available in some countries do not fully meet demand. The building of such facilities is expensive as it requires sophisticated equipment and highly skilled manpower and, as such, needs to be organized at national level in most cases. The absence of such facilities have either led to discarding useful equipment or the improper handling of such repairs in the absence of the necessary facilities.

3.3.2 Regional maintenance facilities

The cost of transport of agricultural equipment to central maintenance facilities is high and certain maintenance activities are not satisfactorily done with mobile or field service. Where large-scale farms are involved, whether private or state-owned, they may find it feasible to organize their own facilities. However, as regards the small emergent farmer or peasant farmer, there is a need to organize such facilities close-by to minimize transport. With longer distance the farmer needs to travel, he may find it hard to disengage himself from his equipment for fear of not receiving it in time. For lack of maintenance facilities close-by he is tempted to continue utilizing his equipment without maintenance or in the incapacitated condition. This could lead to major break down and failure of critical parts which would shorten the useful life of the equipment in question. The absence of such a net-work of facilities close to the farmer is a major constraint.

3.3.3 Basic maintenance facilities

Whether it is a question of animal draught technology or mechanical powered technology, there is the need to build some rudimentary service and repair capability for all sizes of farm units close-by. The establishment of such facilities by individual farms, in particular by the peasant, is not possible. Farmers are unable to maintain their simple tools and implements for lack of such facilities. To get such services they have to travel long distances. Such services would have been conveniently organized if farmers were organized into producer and service cooperatives. Basic facilities could be organized at and/or co-operative centers and thereby within easy reach of the farmers. But such producer/service cooperatives are either non-existant or are in the process of being organized. Some countries, however, are positively progressing in this direction.

In the absence of cooperatives, village black-smiths could be organized to cater for such services. However, the latter are only present in few countries and fewer locations to make an impact. Further, these village black-smiths need to be up-graded. Because of their sheer number and dispersion, much effort is required to create capability to fully cater for such services.

3.3.4 Auxiliary and support facilities

Mechanical workshops : Not all agricultural equipment parts and components are disposable because they are worn out. Some components can be repaired or reworked to be used for second and third cycles. The ability to perform such reworks would significantly reduce maintenance costs. For this, well organized mechanical workshop are required. Such facilities are costly and are not viable in all cases. The limited number of such workshops available in some African countries are mostly located in urban areas far from sites entailing travel of long distances and long queues. The strengthening and development of a net-work of such facilities will significantly enhance maintenance. Such facilities could also be used to manufacture some critical units until original parts are received.

Supply of raw materials and spares : The scarcity of raw materials and spares is a major constraint. The problems related to raw materials and spares can be summarized as follows:

- Raw materials : Steel and steel alloys in particular are imported materials and, therefore, face the same foreign exchange constraints As a result, they are not available in the quantity or quality required. Furthermore, lack of capability to identify, test and verify the right specifications for materials is a major short coming in Africa. The maintenance problem of locally manufactured agricultural equipment is further compounded by the use of poor quality materials.

- Spare parts : The problem of spare parts emanates from :
  - large number of makes and models;
  - inappropriate equipment package;
  - inexperienced operators, improper use of machines;
  - improper maintenance practices;
  - inadequate allocation of foreign exchange;
  - long lead time for acquiring foreign exchange allocation;
  - long lead time for delivery of parts;
  - limited know-how in the management of spares;
  - limited net-work of supply points for spares; and
  - absence of facilities for the manufacture of critical parts.

Due to its essential nature, the problem of spares stands out as the most crucial. The shortage of spares could, however, be significantly reduced if correct maintenance practices are enforced. If planned maintenance is performed to uncover conditions leading to equipment break-downs or harmful deterioration, or equipment is adjusted, repaired, changed or overhauled while these conditions are still in an early stage, parts requirement can be minimized and the need for urgent spares can be avoided.

3.3.5 Technical assistance

Agricultural equipment, in particular those that are non-traditional, are new to African countries. Besides, because of the wide range of available technological packages, their proper utilization and maintenance is complex. The building of infrastructures, the formulation of policies and the introduction and implementation of maintenance systems will be ineffective unless the end users are given training in the new equipment package and systems. Obviously, technical assistance is required for the transfer of know-how

Technical assistance from suppliers to introduce new equipment, technical assistance from international and national institutions in the training of personnel, in building the physical facilities, in improving the maintenance system, and in the implementation of correct procedures is required. Technical literatures, such as service manuals, repair manuals and parts catalogue have to be made available in the language users understand.

At present, most suppliers advertise the availability of technical assistance in creating users capabilities. They have not, however, gone beyond sales propoganda. Several technical packages, both from bilateral and international sources, are delivered. Unfortunately, they, for lack of proper identification of needs, re-direction towards actual needs and coordination, have not registered marked changes when viewed in relation to the amount of resources expended.

3.4 Manpower

Efforts to be made for the implementation of even a well developed maintenance plan be justified only when there are trained personnel to put the system into operation. Manpower development is a costly and time consuming exercise. Trained manpower is key to maintenance improvement programmes.

Improved technological packages in agricultural mechanization are recent innovations and, as such, without a structured manpower development plan, it is hard to expect any success from their introduction. The availability of skilled operators or technicians in Africa is far below the need both in quality and number. Besides, very few African countries have any kind of institutions for the training of maintenance engineers or technicians. Agriciltural machinery, because of their diversity and special applications require specific means of introduction. Eventhough some degree of awareness on the importance of maintenance is visible, redirection of training institutions towards maintenance does not appear to be foreseen.

Lack of incentive schemes for agricultural equipment technicians have, in some cases, resulted in loss of experienced technicians to other sectors. This is partly due to the fact that agricultural equipment maintenance centers are in rural areas and many opportunities exist for skilled technicians in major urban areas. A well designed incentive system for both operator and maintenance crew could result in significantly minimizing maintenance needs, increased productivity and reduced operational costs. For example, a commercial farmer in Zambia who has introduced a system whereby one operator operates the same and the owner personally inspects each machine once a month for defects, including loss of fastners, dried lubrication points, and rewards those operators whose machines passed the tests, claims to have all his machines over 20 years old fully operational.

In addition, the absence of career development plans whereby individuals would be motivated by seeing themselves developing through the hierarchy is a serious shortcoming.

Manpower development need to be addressed far ahead of the introduction of new technology. However, such a practice is not being given due consideration.

3.5 Linkage with research, production, extension and maintenance

Improvements, in research and development, manufacture, extension and maintenance of a technological package require strong intra-linkages Research on evaluation and improvement of existing technology or on design and development of new ones, requires feedback from industry/production problems and constraints; from extension services on adaptability, acceptance by end users, and operational problems; and from maintenance on the quality of products and maintenance constraints. Similarly, for a maintenance improvement programme, information on design changes, manufacturing changes and feed-back from extension on field problems are pre-requisites. To facilitate communication of information and continuous consultation, a working framework is absolutely desired.

At present, in most African countries, because these aspects of a technological improvement programmes are under the supervision of different ministries, cooperation, either at the top or at field level, is poor. As a result, agricultural machinery development and manufacture is constrained. Break-through in developmental work resulting in acceptable designs which bring significant changes has not happened. It is observed that in some countries in addition to developing independently of each other, in some areas there is significant duplication of effort. The problem of coordination has different faces in market economy and planned economy countries. In market economy countries, distribution and maintenance is in the hands of the private sector while extension and research is in the public sector. Under such conditions, each business entity operates virtually independently, each guided by its own interest. In planned economy countries, environmental conditions for better cooperation exists. However, because of lack of flexibility and lack of policy orientation it has not been effectively utilized. Furthermore,the division of responsibilities in such countries are not clear always. For example, certain activities related to maintenance are left unattended. These include the delivery of spares and after sales services.

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4. APPROACHES TO IMPROVING MAINTENANCE

Introduction of a programme for improving maintenance of agricultural equipment requires different approaches depending on the degree of constraints prevailing in a given country. Addressing issues related to each specific country can only be elaborated after a review of the existing situation. Among the many factors affecting the choice of approach include:

- The nature of the country's economy (whether planned or mixed);
- The size, relative importance of the different systems of agricultural practices (irrgated, rainfed, large scale or small holders, etc.) ;
- The level of technology in existance, short and long term trends of agricultural mechanization policies;
- Population of farm equipment;
- The level of infrastructural development, including support services, and
- Whether maintenance is organized for own fleet or for service to others.

Here an attempt is made to indicate the general approach to be followed in introducing a maintenance improvement programme with some references to the differences between planned economy and market economy countries and to whether maintenance is organized for own fleet or for service to others. An indication of how an agricultural equipment maintenance improvement programme cycle would look like is given in Chart 1.

4.1 Assessment of maintenance needs

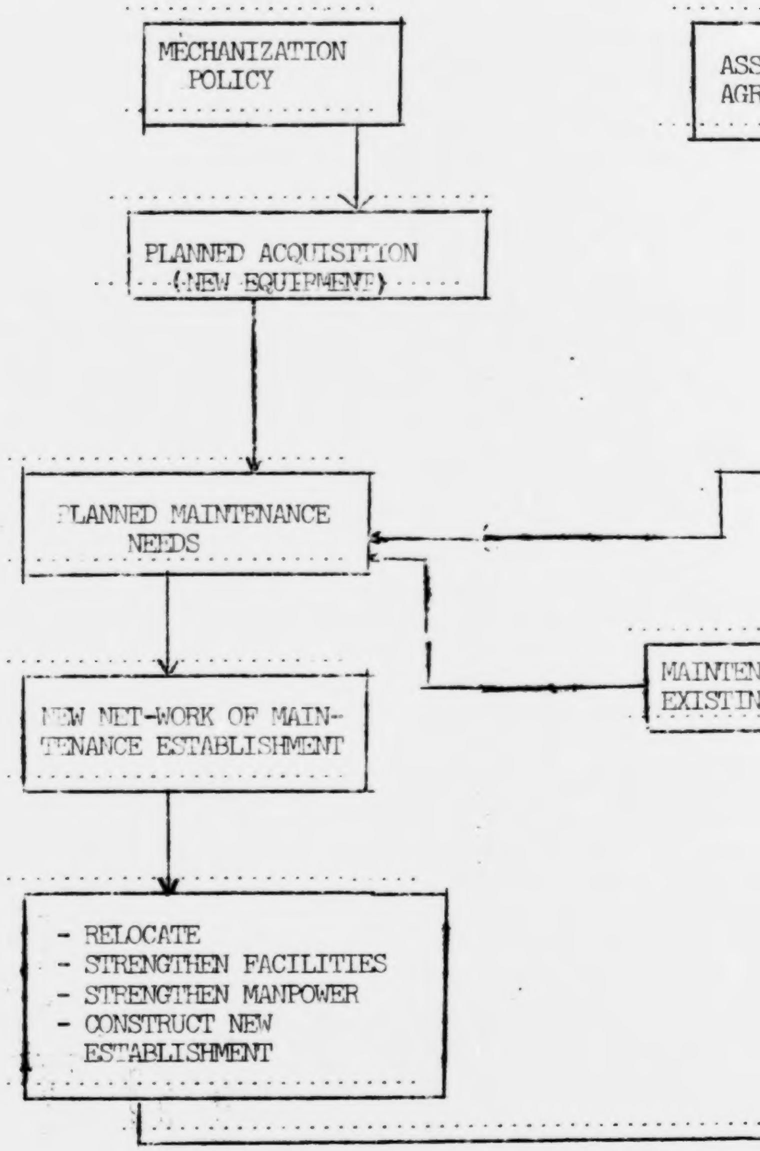
Whether at national or farm level, prior to engaging oneself in a maintenance improvement programme, it is necessary to assess maintenance needs. Maintenance needs of agricultura equipment are dependent on the type and population of equipment. Planning of maintenance improvement programme at national level requires the identification of the:

- population of equipment by type;
- population of equipment by user; and
- population of equipment by location.

Population of equipment by type

Agricultural equipment packages, as noted earlier, consist of a wide variety of components. The type of maintenance required and the frequency of maintenance needs are different from equipment to equipment. In order to arrive at the total magnitude for each level of maintenance, equipment population by category and class is required. This will enable to define overall infrastructural requirements, labour requirements and all auxiliary services needed. As dealing item by item would be impractical, equipment would need to be dealt in groups. Table 1 presents such grouping.

Chart 1. Flow chart of agricultural equipmen


MECHANIZATION POLICY
ASS
AGR
PLANNED ACQUISITION (NEW EQUIPMENT)
PLANNED MAINTENANCE NEEDS
MAINTEN
EXISTIN
NEW NET-WORK OF MAINTENANCE ESTABLISHMENT
- RELOCATE
- STRENGTHEN FACILITIES
- STRENGTHEN MANPOWER
- CONSTRUCT NEW ESTABLISHMENT

maintenance improvement programme cycle

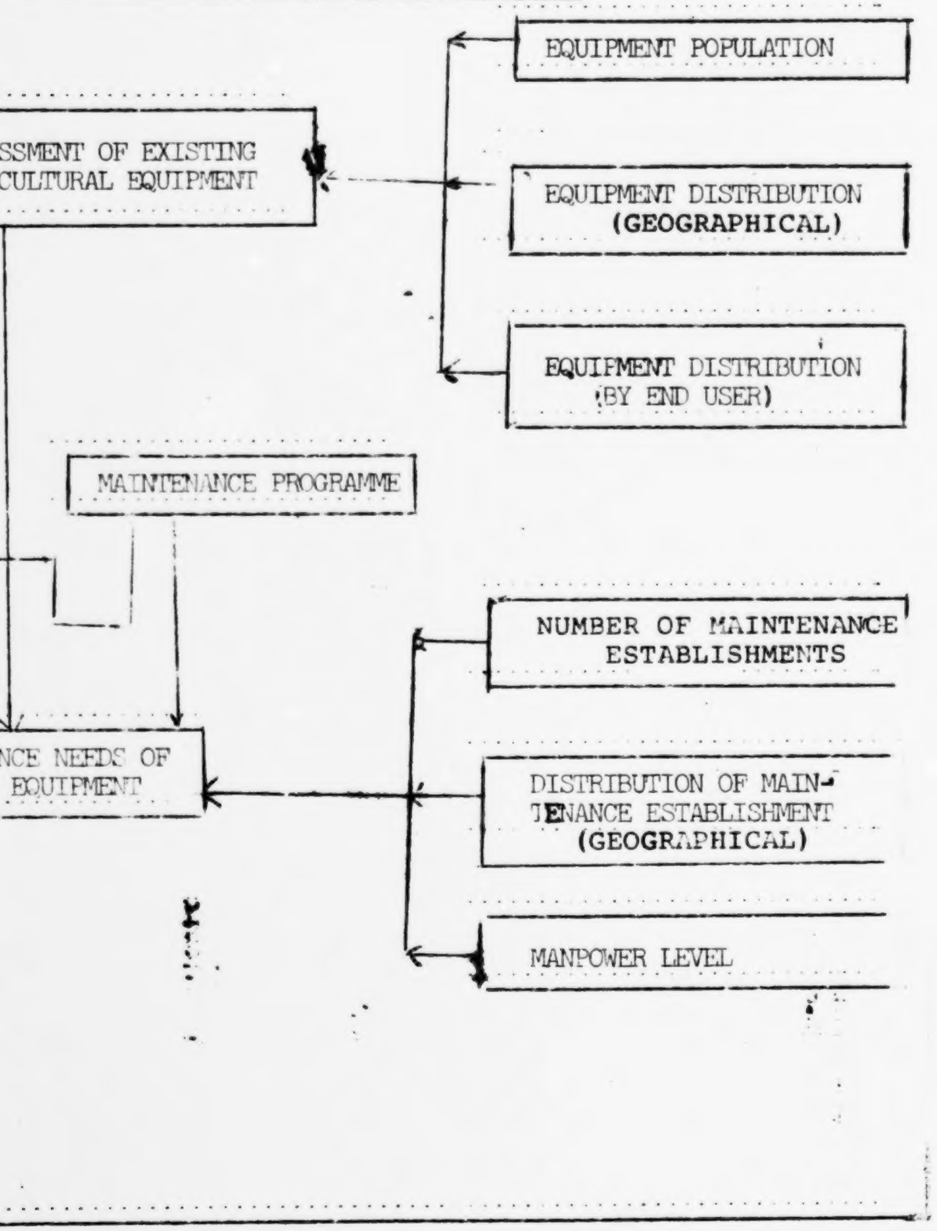

EQUIPMENT POPULATION
SSMENT OF EXISTING
CULTURAL EQUIPMENT
EQUIPMENT DISTRIBUTION (GEOGRAPHICAL)
EQUIPMENT DISTRIBUTION (BY END USER)
MAINTENANCE PROGRAMME
NUMBER OF MAINTENANCE ESTABLISHMENTS
NCE NEEDS OF
EQUIPMENT
DISTRIBUTION OF MAINTENANCE ESTABLISHMENT (GEOGRAPHICAL)
MANPOWER LEVEL

Table 1 : Suggested classification of agricultura

Category	Class 1		
	Type	Examples of types	Ty
1.Hand tools	Simple tools	Hoes, axes, sickles, machets, pick-axes, shovels, walking sticks planters, forked hoes	Si im me
2.Animal-drawn implements	Simple elements	'Maresha' and board ploughs, cultivators, harrow disks, spike tooth	Mu pl el en
3.Self-propelled machinery	Light	Power tillers, moterized knap-sac sprayers, tractors upto 50 HP, threshers manual feed, shellers, electric centre fugal pumps, trailers, etc.	Mo
4. Trailed/drawn implements and machinery	Simple drive	Sub-soilers chiesel ploughs, mould board ploughs, disc ploughs cultivators, land levelers, ridgers	Co dr

equipment

Class 2		Class 3 heavy duty	
	Examples of types	Type	Examples of types
ple le- ts	Manual wheeled seeders, fertilizer drills, spreaders, knapsac sprayers (manual)		
ti- m- s	Tool bard, land levers, planters, seed drills		
ium	Tractors 50-100 HP trailed harvestors, diesel pumps and generators, submersible pumps, etc.	Heavy	Tractors above 100 HP, combine harvestors, sprinkler irrigation systems, dozers, graders, scrappers, loaders, etc.
lex es	Planters, seed drills, direct drills, spreaders, sprayers		

Population of equipment by user

Making inventory of agricultural equipment by users will make it possible to identify the levels of maintenance needs to be addressed by each type of user and the services demanded. For the purpose of this publication, the following classification of users is recommended :

- Small holder upto 2 hectars;
- Small holder with 2-10 hectars ;
- Commercial farmer or cooperative upto 100 hectars ;
- Commercial farmer or cooperative with 100-2,000 hectars and tractor hire schemes with upto 20 tractors ;
- Commercial farmer or cooperative with 2,000-6,000 hectars; and
- Commercial farmer or cooperative above 6,000 hectars and tractor hire schemes above 100 tractors.

Population of equipment by location

Distance is a critical factor affecting the kind of net-work of maintenance facilities to be organized. Population by location can be established following administrative subdivisions or zones. As the concept of administrative division differs from country to country, the following have been assumed for the purpose of this publication :

- Zone : The first administrative sub-division in a country with territorial coverage of upto 150-200 km in radius;

- District: The next lower administrative sub-division with territorial coverage of upto 75-100 km in radius; and

- Sub-district : The lowest administrative sub-division with territorial coverage of upto 30-50 km radius.

The above requirements for planning of maintenance improvement programme at national level also apply at operational level.

Once the population of equipment is known, the actual type of maintenance required by each category needs to be estimated. The type of maintenance work for agricultural equipment would comprise :

- Inspection : This consists of periodic checks to be made on equipment either through visual, instrumental or operational means to establish the condition of equipment and to determine needs for repairs in order to prevent interruption of operating equipment. Inspection activities vary in intensity depending on the different levels of technology.

- Service : Service is maintenance performed on equipment on scheduled bases covering the cleaning and application of lubricants and consumables.

- Preventive maintenance : This covers activities performed on equipment to avert harmful conditions through adjusting and replacement of parts and components. It comprises maintenance work prescribed to be performed at intervals throughout the life of the equipment. Like inspection, preventive maintenance activities vary in intensity and content depending on the levels of preventive maintenance involved.

- Break-down maintenance : This covers maintenance that is performed after the observation of defect or occurrence of failure of equipment or its components. It entails, in most cases,repairs or replacement of parts and components.

- Overhaul : Overhaul is a maintenance activity done on equipment and involves the total disassembly, repair, replacement and re-assembly of all components with the aim of extending the useful life of equipment.

Estimates of the frequency of the different kinds of maintenance for the different categories of equipment is given in Table 2 along with labour hours required.These estimates of frequency can vary depending on the working conditions, environment and the level of maintenance facility as well as on whether strict planned maintenance programmes are followed or not. Estimates for break-down maintenance are not given as these depend on many external factors and therefore need to be established on the basis of local experience. Inspection preventive maintenance comprise three levels indicating weekly,monthly and quarterly for lighter category of equipment and monthly, quarterly and yearly for heavier categories. Frequency with longer intervals are given in terms of fractions.

Table 2 : Estimates of maintenance frequency and labour ti

Category	Class	Service				Inspec		
		1st		2nd		1st		2n
		F	T	F	T	F	T	F
Hand tools and implements	Simple tools	-	-	-	-	-	-	-
	Simple implements	2	$\frac{1}{4}$	-	-	-	-	1
Animal-drawn implements	Single elements	2	$\frac{1}{4}$	-	-	-	-	1
	Multiple elements	4	$\frac{1}{4}$	-	-	4	$\frac{1}{4}$	1
Self-propelled equipment machinery	Light	4	$\frac{1}{2}$	1	1	4	$\frac{1}{4}$	1
	Medium	4	1	1	4	4	$\frac{1}{2}$	1
	Heavy	4	1	1	$\frac{1}{2}$	4	$\frac{1}{2}$	1
Trailed implements	Simple drives	4	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	4	$\frac{1}{4}$	1
	Complex drives	4	$\frac{1}{2}$	$\frac{1}{3}$	1	4	$\frac{1}{2}$	1

F = Frequency (number of times per month).
T = Time (hours it takes to do the service).

e

ion			Preventive						Overhaul	
	3rd		1st		2nd		3rd			
T	F	T	F	T	F	T	F	T	F	T
–	1/3	1/4	–	–	1	1/4	1/3	1/2	–	–
1/2	1/3	1/2	–	–	1	1/2	1/3	1	–	–
1/2	1/3	1/2	–	–	1	1/2	1/3	2	–	–
1/2	1/3	1	–	–	1	1	1/3	4	1/12	8
1	1/3	4	1	4	1/3	8	1/12	16	1/48	48
1	1/3	4	1	8	1/3	8	1/12	16	1/48	96
1	1/3	8	1	8	1/3	16	1/12	32	1/48	144
1/2	1/3	2	–	2	1	4	1/12	8	1/24	24
1	1/3	4	–	4	1	8	1/12	16	1/24	48

1st = Biweekly/weekly or monthly.
2nd = Monthly/quarterly.
3rd = Quarterly/yearly.

4.2 Assessment of existing maintenance capacities and capabilities

Once needs at the national or operational levels are established, existing maintenance facilities should be exhaustively reviewed prior to building additional facilities.This entails detailed assessment of existing capicities and capabilities. All relevant institutions engaged in the delivery of maintenance services for agricultural equipment should be surveyed. To facilitate undertaking such a survey and subsequent analysis, a system of classification of maintenance institutions is needed. A typical questionnaire which can be used for this purpose is attached in Annex 1. The main items covered are :

- Location
- Infrastructure
- Building
- Equipment
- Manpower
- Organization
- Support services
- Financial
- Target users

Using the information acquired through the survey, institutions should be classified, particularly if such an assessment is to be done at national level. The following classifications have been adopted for the purpose of this publication:

Class 1

Artisanal : Maintenance facility owned and operated by individual or family,employing up to five full-time or part-time labour and using shed or small room equipped with hand tools for repair of farm tools and small implements.

Class 2

Basic service station : Maintenance facility owned and operated by a small commercial farmer or cooperative or private entrepreneur employing up to ten persons on full-time basis and using a shed or enclosed semi-permanent or permanent building capable of housing a tractor for maintenance and equipped with hand tools and small workshop equipment to execute basic routine services and repairs on farm equipment for categories 1, 2, 3 and 4 and classes 1 and 2 for a population upto 20 tractors and associated implements.

Class 3

District workshop (farm workshop): Maintenance facility owned or operated by a big commercial farmer or cooperative or dearler employing up to a total of 30 - 50 persons and including all the facilities of a basic service station expanded to cater for basic routine maintenance and repair, including replacement of components and parts for all categories of agricultural equipment for a population of up to 50-60 tractors and associated implements. Facilities should include space for the repair and maintenance of electrical parts and types, washing and lubrication along with a small office and parts store.

Class 4

Regional (zonal) workshop : Maintenance facility owned and operated by a dealer or a large state enterprise employing up to 150 employees. It should include buildings with all facilities of a district workshop and additional facilities to overhaul components, such as engines and gearboxes and perform major repairs on all categories of agricultural equipment.

Class 5

Central workshop : Maintenance facility owned and operated by a dealer or a state enterprise with all the facilities of a regional workshop in addition to capacity to rework or fabricate parts and components of agricultural equipment.

Class 6

Auxiliary workshop : Maintenance facility not fully or specifically equipped for the maintenance of agricultural equipment. It comprise services, such as washing and greasing, tyre repair, battery services, repair of electrical components and repair of hydraulic components.

4.3 Establishing net-work of maintenance and related services

Application of low level technologies in African agriculture is cited as a major factor suppressing agricultural productivity. Though it is recognized that increased use of higher level technologies is a matter of necessity for increased agricultural productivity, current level of prices of agricultural machinery and parts and Africa's ability to handle properly acquired equipment have stunted the effort. This is further aggravated by low economic growth of these countries which among others is manifested by the scarcity of foreign exchange. In a nut-shell, Africa is either unable to promote the use of higher technologies through increased inputs or maximize use of acquired equipment for the lack of adequate spare parts or provision of quality maintenance services. The need to build capabilities to ensure extended use of equipment is acute. Extended use of agricultural equipment with minimal expenditures of foreign exchange is possible if capacities for delivery of planned preventive maintenance as well as regenerate used parts and components are built. Among the priority action to ensure building up of such capacity is to establish net-work of maintenance and related services at national, subregional or regional levels. Establishing net-work of maintenance and related services requires huge investment and therefore, national Governments would be advised to create conducive environment for the setting-up and operating of such establishments.

Once maintenance needs are assessed as outlined in section 4.1, existing facilities surveyed and classified, and demand/supply gaps determined, the first step to be undertaken is to optimise the use of existing facilities and capabilities. This would require developing an optimal network of maintenance systems. Indications as to how this could be done are given in the paragraphs that follow.

Artisanal work stations should be established within walking distance of farmers at district level to meet peasant needs. Their number should be such that each station has enough work and its capabilities are fully utilized. Such stations should be capable to give services to all equipment in categories 1 and 2.

Basic service stations should be established within a district to meet needs of peasants, small commercial farmers, cooperatives and tractor hire schemes. They should be located close to where basic infrastructures are available. They should also be at distances easily accessable by farmers so that farmers are able to come and receive basic services and return the same day. Depending on the equipment population and category, basic service stations may be established within a radius of 10-15 kilometers to service 10-20 tractors and associated equipment and implements. Basic service stations should provide maintenance for categories 1,2, and 3 (class 1) and category 4 (class 1).

District workshops (farm workshops) should be established within a region or zone to meet the needs of farmers using equipment in categories 2,3 and 4. They should be located within short distances from farm using their services. A maximum distance of 50 kms. is recommended. Such a unit may be considered within an area where agricultural equipment population comprises 60-100 tractors. District workshops should provide preventive maintenance and repairs (short of overhauling) to all equipment categories.

Regional (zonal) workshop should be established to meet major repairs and overhauls of agricultural equipment within a region* where they are located. There should be adequate built-in flexibility in the design of regional workshops to accommodate variations in maintenance needs.

Central workshops whose number and complexity should be determined taking into account auxiliary facilities in existance should be established. A central workshop may be established where there are 3-4 regional workshops. Where central workshops are not justified, consideration should be given to establishing workshops for specific services.

Following the above guidelines, optimum network can be planned and short and long-short and long-term development strategies for a maintenance improvement programme formulated.

4.4 Optimization of existing capabilities and capacities

The first task of an improvement programme, once demand/supply gaps are established, is the optimization of the use of existing facilities. During the process of working out optimal solutions taking account of existing facilities, several conditions may arise. These include :

- That the total number of units in each level is inadequate;
- That the number of units of one level may be in excess while that of another level, inadequate;
- That the number of units of one level may be in excess in one district while inadequate in another;
- That the facilities are adequate but manpower is inadequate;
- That both manpower and facilities are in excess;
- That manpower and facilities are adequate but skill levels are low;

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*Regional workshops (zonal) should be build incorporating farm workshops for the district.

- That facilities and manpower are adequate, equipment population are sufficient but requests for maintenance services are not forthcoming;

- That facilities and manpower match but demand is more than planned;

- That facilities and manpower match the need but productivity is low

On the basis of the conditions revealed in any one situation, either at national or operational level, the following should be carried out before additional infrastructure or institutions are considered for an improvement programme :

- Investigations of the possibilities for relocating;
- Investingations of the possibilities for up-grading;
- Investigations of the possibilities for strengthening or increasing capacities of existing units through the incorporation of missing equipment;
- Adequate manning of the facility with the required skilled technicians or upgrading the skills of existing manpower;
- Considering regional cooperation where population of equipment does not justify own facilities (central workshops in particular);
- Investigations of the possibility of instituting extension services to sell the idea of preventive maintenance and the advantages of proper maintenance by qualified personnel in an appropriate environment;
- Investigations of incentive schemes for workers with a view to motivating them to increase productivity.

If and when optimization of existing facilities are exhausted, the question of establishing new institution need to be addressed. The development of an optimal net-work in planned economy countries, where the primary responsibility for building capacities is in the hands of the state, is much simpler. Where the economy is oriented towards market economy and where maintenance rests on the private sector much effort is needed to regulate and redirect the development and operation of maintenance establishments. Regulatory measures should be used to force or encourage dealers and suppliers to build facilities following optimal solution. It is the tendency of most dealers to concentrate at major urban areas where equipment sales is high. To ensure a fair distribution of maintenance facilities, the designation of market areas may be advisable.

4.5 Maintenance programme

The building of maintenance infrastructure provides the capacity to execute maintenance, but this does not ensure neither the effectiveness nor the minimization of cost of maintenance. The overall objective is not the volume of maintenance work performed but rather the effective reduction of farm costs, i.e. increasing productive hours at minimum maintenance and operational costs. This further means reduction of maintenance labour time, minimizing parts usage, shorter maintenance down time and lower usage of consumables, such as fuel. To achieve these, two important issues need to be addressed : the introduction and application of sound maintenance procedures and deployment of adequa number of qualified personnel. In this section a brief outline of a maintenance programme is treated while the question of manpower is delt in section 4.6.

There are two approaches to maintenance programme, i.e. break-down maintenance and preventive maintenance.

Break-down maintenance is a practice of repairing equipment after a failure has occurred or been observed. The equipment operates until it fails to perform. Such a practice makes planning of maintenance work and parts and staff requirements almost impossible. It is accompanied by total replacement of parts without the possibility of recycling of parts and does often lead to longer down time.

Preventive maintenance is a maintenance programme whereby periodic checks and maintenance are performed on equipment on regular basis with the aim of either uncovering conditions leading to equipment break-down or preventing equipment from damage through adjusting, repairing, changing or overhauling of equipment or parts while wear and tear are at an early stage. Planning maintenance work and parts and manpower requirements is, therefore, made possible through preventive maintenance.

Agricultural equipment are used under a tight time schedule during specific periods of the year. This is why preventive maintenance programme is particularly appropriate for such equipment. Inspections and preventive maintenance works could be performed on regular basis during slack periods to make the equipment available during critical periods.

Manufacturers of equipment normally prescribe a series of maintenance activities (often on hours worked) to be performed on equipment. These maintenance activities consist of routine inspection, periodical services, scheduled preventive maintenance and overhaul. To ensure effective utilization of available facilities, a system by which maintenance work is planned, estimated, scheduled, monitored and reported has to be elaborated. In order to map out maintenance plans and make estimates of work load, labour and material inputs, an inventory of the equipment catered for have to be made as well as an identification system by which each individual equipment is identified need to be introduced.

The implementation of preventive maintenance could be easily instituted in user organized maintenance facilities provided there is commitment by management. However, its implementation, where maintenance facilities are organized for other users, may prove to be difficult. First, equipment owners may consider it unwise to spend money on maintenance and may fear that productive hours are lost while performing preventive, maintenance. Secondly, for fear of not getting equipment returned on time, they do not want to part with their equipment. In order to minimize these constraints the following programmes may be instituted :

- Operate mobile maintenance crew to perform most inspection and light preventive maintenance on farm site.
- Establish a contracting scheme whereby users are requested to sign a maintenance contract for preventive maintenance, for a fixed period to start with. This way, users become aware of costs of maintenance in advance and can be convinced to participate in the scheme.
- Maintenance can be planned so that mobile teams can be effectively scheduled, thereby significantly reducing travel time as well as overall cost of maintenance. This will enable maintenance institutions to make timely provision for parts and labour.
- Have some key equipment available for replacement on cost basis in case equipment is required during a period of extended maintenance.

To ensure effective implementation of a maintenance programme, detailed procedures need to be outlined in a maintenance procedures manual.

4.6 Manpower Development

Manpower development need to be considered from two angles: the first to meet new demands, the second to increase internal capabilities and to motivate workers.

Skilled manpower is required in large numbers if mechanization is to be promoted in African agriculture. Increasing sophistication of technology and number of equipment require higher skills in larger numbers. This points out to the need for manpower development programmes geared towards agricultural equipment maintenance, both at the national and institutional levels.

At national level, vocational schools and polytechnics should develop programmes to train mechanics and technicians while colleges and universities to train maintenance engineers. In-service training for artisans should be organized to orient them in some of the basic principles of maintenance.

At the institutional level, training units need to be strengthened and/or established to conduct orientation courses for new entries, familiarization courses on new equipment, skill refresher courses and up-grading programmes. Special programmes for supervisors on maintenance management should also be organized.

In addition, schemes must be instituted whereby workers are given opportunities for continuing their education. This would involve classifying workers into groups by functions and working out a system which would enable workers to go up the ladder through an up-grading process. The scheme would permit good and productive workers to be given training opportunities and compete for higher positions, thereby providing a mechanism for motivating workers.

4.7 Support facilities

Availability of raw materials, spare parts and consumables in adequate quantities is among the key factors that could ensure the success of a maintenance improvement programme. Supply of materials has to be organized parallel to a maintenance system. This envolves stocking of materials which ties huge amount of resources necessitating the installation of material management system which ensures the holding of minimum levels of essential inventories. In this connection, it should be notedthat inventory management in developing countries has been a major factor contributing to the inefficiency and failure of production and maintenance facilities. Systems and mechanisms for efficient material management should therefore be developed. Several techniques are available and could be adapted to attain a satisfactory level of efficiency in inventory management. The present level of costs of micro-computers and available inventory control soft ware packages have made the installation of electronic data processing system a viable solution. The installation of computerized inventory control system is highly recommended. For the maintenance of agricultural equipment, minimum stock should be held at district and central workshops. As holding a full range of spare parts and consumables by each maintenance center is uneconomical, a less costly system for processing, stocking and distributing [illegible] devised. This could be done by establishing a central organization and a net-work of branch distribution centers specifically organized for this purpose.

5. BASIC REQUIREMENTS OF MAINTENANCE INSTITUTIONS

Following the overall framework of maintenance establishments discussed in section 3.3, Chapter 3, this chapter deals with basic requirements that should be taken into account when considering guidelines for designing an improvement programme. Such a programme is expected to serve as basis for developing programmes tailored to specific needs and conditions prevailing in anyone African country. The basic requirements are elaborated under the following headings :

- Facilities
- Organization
- Management systems
- Financial

5.1 Facilities

Facilities, primarily, consist of buildings, equipment and utilities that are located on the site. Indications of the general requirements for each level of maintenance establishment are shown in table 3.

5.1.1. Site

See Table 3.

5.2.2 Building

Building requirements differ significantly depending on type of equipment population and environmental conditions. Table 4 gives indications of general requirements as general guidelines for planning. Indications are given in terms of total area under-cover with suggestion on the number and size of work bays and types of specialized shops to be included, office and storage space needs. An indication on suggested type of construction is also given.

5.1.3 Equipment and tools

Equipment and tools required for maintenance are indespensable elements for a successful implementation of an efficient and effective maintenance programme. Absence of appropriate tools and equipment in adequate number adversely affect labour productivity as well as quality of repair. Equipment and tools consist of standard tools and equipment normally used for general maintenance activities and those required for servicing specific equipment. The need for special tools and equipment can be obtained in most cases from suppliers at the time of purchase. Indications of standard tools and equipment by type are given in table 5. Quantities and sizes depend on the volume of work and type of equipment to be maintained and, therefore, should be fixed at the time of implementation.

5.1.4 Utilities

The type, capacity and magnitude of utilities required for each level of maintenance institution, are indicated in table 6. Exact capacities can only be determined when the list and characteristics of the maintenance equipment is known.

5.1.1 :Site

Table 3 : Proposed general site requirements for maintenance establishments

Requirement	Establishments				
	Artisanal	Basic service station	District workshop	Regional workshop	General workshop
Location	Village	- On farm, in case of commercial farm - Rural town in case of running co-operative or private entrepreneur	- On farm, in case of commercial farm - Rural town, in case run by a cooperative or private entrepreneur	Town	Town
Total site area	upto 100 m^2	upto 500 m^2	upto 3,000 m^2	upto 10,000 m^2	upto 10,000 m^2
Built up area	upto 50 m^2	upto 300 m^2	upto 2,000 m^2	upto 3,000 m^2	upto 5,000 m^2
External parking area in terms of number of machines	Not required	upto 2	upto 12	upto 36	upto 36

Table 4: Indications of building requirements for maintenance establishments

Requirement	Establishment				
	Artisanal	Basic service station	District workshop	Regional Workshop	Central workshop
Total covered area	upto $30m^2$	upto $150\ m^2$	upto $800\ m^2$	upto $3,000\ m^2$	upto $3,000\ m^2$
Size of repair area in terms of workbays	2 small[a/]	4 medium[b/]	6 medium 2 big[c/]	8 medium 2 big	8 medium 2 big
Shops : - Component overhaul	NR	NR	NR	For engine and power - train repair and overhaul	For engine and power train repair overhaul and rectification of components
- Electrical	NR	Station for minor repair of electrical parts	Shop for full fledged repair of electrical components	Shop for full fledged repair and overhaul of electrical components	Shop for full fledged repair, overhaul of electrical components and rectification of parts
- Machining	NR	NR	For turning, grinding and drilling	For turning, grinding, milling and drilling	For turning grinding (surface-cylinderical), milling, boring and honing

NR = Not required.

[a/] Small - Workbay adequate to accommodate light duty stationary equipment.
[b/] Medium - Workbay adequate to accommodate medium sized tractor or similar equipment.
[c/] Big - Workbay adequate to accommodate heavy duty tractors/combine harvesters and the like.

Table 4: Indications of building requirements for maintenance establishments (Cont'd)

Requirement	Establishment				
	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
- Welding and forging	Manual forging station	Station for oxy-acyetelene & electric arc welding and manual forging	Shop for oxy-acyetelene and electric arc welding and manual forging	shop for oxy-acyetelene, electric arc welding and manual forging	Shop for oxy-acytelene, electric welding, mechanical forging and heat tr ment
- Sheet metal working	Station for manual work only	Station for cutting, shearing and manual work	Shop for cutting, shearing,bending and rolling	Shop for cutting shearing,bending and rolling	Shop for cutting,sh ing,bending,rolling blanking and pressi
Battery	NR	Charging	Charging and repair	Charging and repair	Charging and repair
- Tyre	NR	Tube repair	Tube and tyre repair	Tube and tyre repair	Tube and tyre repai
- Washing and greasing	NR	NR	Open plate washing station	High pressure washing with hydraulic lift and chemical cleaning	High pressure washi with hydraulic lift chemical cleaning
- Wood work	Manual	Manual	Manual	Planning and sawing	Planning, sawing and turning
Office	NR	NR	2-3 rooms	upto 10 rooms	upto 10 rooms
Storage: - Parts store/ tool -room	NR	NR	Fast moving parts	Full range of essential parts and supplies	Full range essential parts, raw materials and consumables
- Component storage	NR	NR	NR	Repaired and a waiting repair	Repaired and awaiting repair
Type of Construction	Temporary or permanent (low cost), open/closed	Permanent or semi-permanent,open or closed	Permanent (low cost) partly open closed	Permanent,fully closed	Permanent,fully close

Table 5 : Indicative list of equipment required for maintenance establishments

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
1. Component overhaul	NR	NR	NR	-Valve seat grinder -Arbor press -Engine, gear box and axle stands - Muffle furnace - Parts washing machine - Valve seat cutter - Diagnostic instrument for diesel engines - Stetoscope - Torque wrench - Measuring and tool set for diesel engines - Pedestal grinder - Riveting machine - Gantry crane or bridge crane - Floor crane - Transport carts - Work benches - Engine test stand - Bench grinder - Machanic's tool set - Tap and die set - Hydraulic test bench	Same as for regional workshop

Table 5: (Cont'd)

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
2. Electrical shop	NR	- Electrician tool set - Soldering iron - Volt meter - Ameter	- Universal electric testing machine - Spark plug tester - Tester for ignition and lighting system - Pedestal grinder - Bench drill - Arbor press - Electric hand drill - Soldering iron - Work benches - Portable universal tester	Same as for district workshop Plus - Bench lathe	Same as for district workshop Plus - Bench Lathe -Stator and armature winding
3. Machine shop	-	-	- Pedestal grinders - Drill press - Hydraulic press - Lathe - Work benches - Measuring instruments and tool sets	-Pedestal grinders -Drill press - Hydraulic press - Lathe - Milling machine - Shaper - Measuring instruments and tool set - Work benches - Floor crane - Transport carts	-Pedestal grinders -Drill press -Hydraulic press - Lathe (high speed) - Milling machine - Shaper - Crank shaft grinder - Cylingerical grinder - Tool grinder - Threading machine - Boring and honing machine

Table 5 : (Cont'd)

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
					- Metal spraying - Planting shop - Measuring instruments and tool sets - Work benches - Floor crane - Bridge crane - Transport carts
4 Welding and forging shop	-Hand or electric bench grinders -Charcoal fired furnace with hand or electric operated blower -Anvils -Forger's hamers and tongs -Basic Mechanic's tools -Hand drill	-Welding transformer or generator -Oxy-acytelene welding set with cylinders -Welding accessories -Bench grinder -Hand/angle grinder -Bench drill -Open-hearth furnace with electric blower -Anvils,hammers and tongs -Mechanic's tool set	- Work benches - Carts - Quenching tanks - Welding transformer or generator - Oxy-acytelene welding set with cylinders - Welding accessories - Bench grinder - Hand/angle/ grinder - Bench drill - Open-hearth furnace with electric blower - Anvils,hammers and gongs - Mechanic's tool set	Same as for district workshop Plus -Mig welder -Spot welding machine	Same as for district workshop Plus -Mig welder -Spot welding machine -Pneumatic hammer -Electric heat treatment furnace

Table 5: (Cont'd)

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
5. Sheet metal working	-Lever shear	-Lever shear	-Lever shear, -Manual guilletine shear -Manual folding (bending) machine	-Mechanical gilletine shear -Circular shear manual/electric -Folding and bending machine -Power hack saw -Nibbler - Rolling machine	-Mechanical gilletine shear -Circular shear manual/electric _Folding and bending machine -Power hack saw - Nibbler - Rolling machine - Mechanical eccentric press - Hydraulic or deep drawing mechanical press - Oxy-acyetelene profile cutting machine
6. Battery shop	NR	- Mobile battery quick charger - Cell tester - Hydrometer	-Mobile battery quick charger -Battery charger stationary -Cell tester -Water distiller -Acid pump -Hydrometer -Gas torch	-Mobile battery quick charger - Battery charger stationary - Cell tester - Water distiller - Acid pump - Hydrometer - Gas torch	-Mobile battery quick charger - Battery charger stationary -Cell tester -Water distiller - Acid pump - Hydrometer - Gas torch

Table 5: (Cont'd)

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
7. Tyre shop	NR	- Mounting and dis-mounting stand - Hot plate - Tyre filling gun and pressure gauge	- Mounting and dismounting equipment - Hot plate - Tyre filling and guage	-Mounting and dis-mounting equipment -Hot plate -Tyre filling gun and guage -Volcanizer	-Mounting and dis-mounting equipment -Hot plate -Tyre filling gun and guage -Volcanizer
8. Washing and greasing	NR	-Hand greaser	-Washing plate -High pressure Water pump -Oil dispenser -Grease pump	-Washing plate -High pressure -Cold and hot water pump -Oil dispenser -Grease pump -Hydraulic car lift -Chemical cleaning for components	-Washing plate -High pressure -cold and hot water pump -Oil dispenser -Grease pump -Hydraulic car lift -Chemical cleaning for components
9. Work bays line main-tenance	-Work benches with vice -Washing bath -Mechanic's tool set	-Work benches with vice -Washing bath -Hydraulic jack -Gantry crane -Floor crane -Mechanic's tool set -Special tools	-Work benches with vice -Washing bath -Hydraulic jacks -Gantry crane -Floor crane -Mechanic's tool set - Special tools - Bench grinders - Bench drill	-Work benches vice -Washing bath -Hydraulic jack -Gantry crane -Floor crane -Mechanic's tool set -Special tools -Bench grinders -Bench drill	-Work benches with vice -Washing bath -Hydraulic jack -Gantry crane -Floor crane -Mechanic's tool set -Special tools -Bench grinders -Bench drill

Table 5 : (Cont'd)

Location	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
10. Wood and upholstery workshop	-Carpenter's hand tools	- Carpenter's hand tools -Work benches -Wood hand drill	-Sawing machine -Planner -Combined wood working machine -Carpenter's hand tools -Bench grinder -Drill press -Electric hand drill	-Band saw -Circular saw -Planner -Wood working/ lathe -Sawing machine -Belt sanders -Bench grinder -Drill press -Hand drills -Carpenter's hand tools	-Band saw -Circular saw -Planner -Wood working lathe -Sawing machine -Belt sander -Bench grinder -Bench grinder -Drill press -Hand drills -Carpenter's hand tools
11. Painting	NR	NR	- Manual	-Paint spray gun -Paint mixer -Compressor	-Paint spray gun -Paint mixer -Compressor
12 Tool room	NR	NR	-Set of special tools -Set of mobile equipment -Set of mechanic's tools -Set of electrician tools -Set of measuring tools	-Set of special tools -Set of mobile equipment -Set of tools for . mechanic . electrician . Carpenter . Welder . Machinist . Blacksmith -Set of measuring tools and instruments	-Set of special tools -Set of mobile equipment -Set of tools for . mechanic . electrician . carpenter . welder . machinist . blacksmith - Set of measuring tools and instruments

Table 6 : Indications of utilities requirement for maintenance establishments

Type	Artisanal	Basic service station	District workshop	Regional workshop	Central workshop
Water	Very low, at level of human need	Very low, continuous supply	High, Continuous supply	Very high, Continuous supply Hydrant	Very high, Continuous supply Hydrant
Power	NR	Single phase, central or own generation, upto 5 kw.	Three phase, central or own generation, upto 50 kw	Three Phase, central, over 100 kw	Three phase, central, over 150 kw
Compressed air	Nr	Self propelled or electric, 6 Kg/cm2	Electric with receiver, 10 Kg/cm^2	Electric, central, system, 10 Kg/cm^2	Electric, central, system, 10 Kg/cm^2

NR = Not required.

5.2 Organization

Proposals related to organization covering ownership, status, organization chart, key functions of the different levels of maintenance establishments and staffing are briefly outlined below :

5.2.1 Artisanal

Ownership : Private or family (sole proprietor).

Organization : No formal organization required.

Key function : Perform repair work on hand tools and animal drawn farm implements by manual grinding and forging techniques.

Staffing : Two skilled blacksmiths and one helper.

5.2.2 Basic service station

Ownership : Private, large family or cooperative or small enterprise if independently organized as a unit of a bigger organization.

Organization : One single team.

Key function : Perform minor repair and light preventive maintenance on farm implements and propelled equipment (welding, sharpening, replacing of parts, lubricating, adjusting and charging of batteries).

Staffing :

Table 7 : Proposed staffing of a basic service station

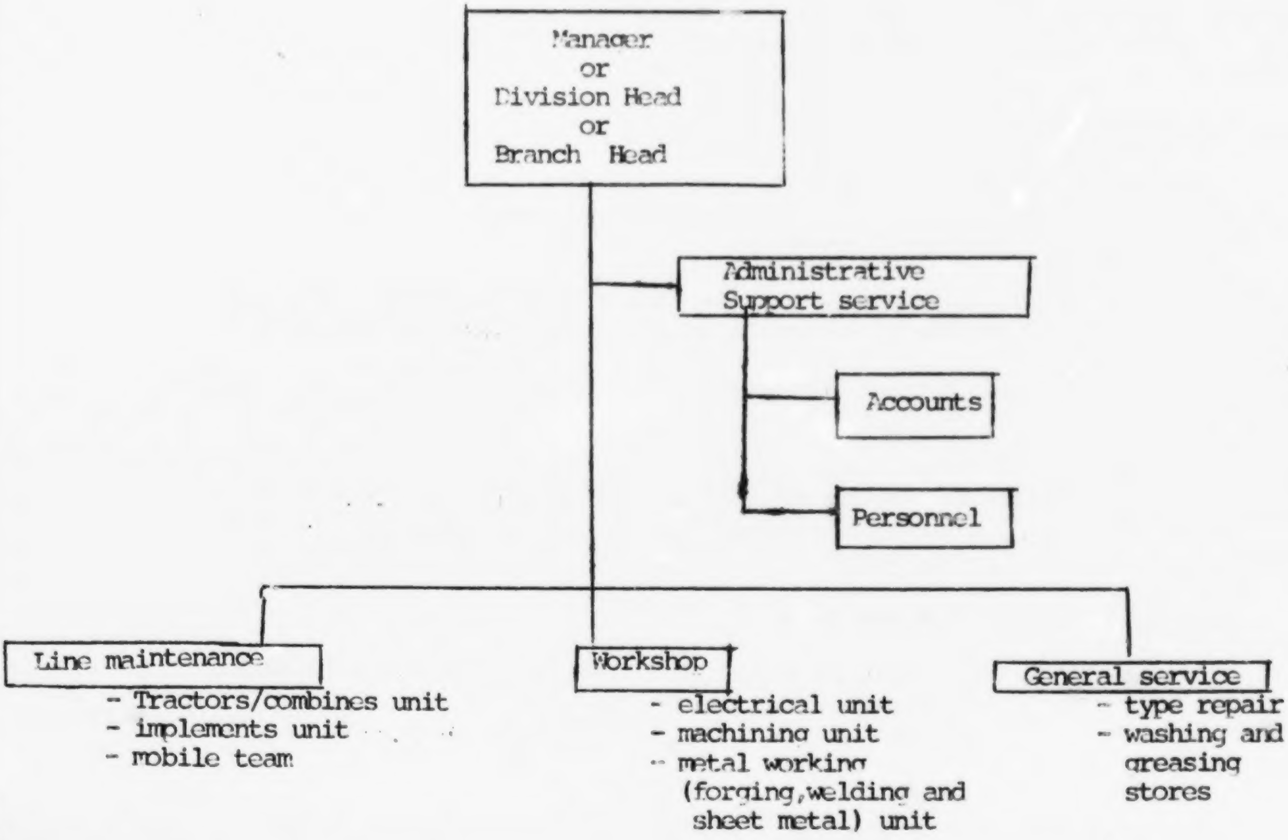
Senior technician	1
Mechanics	2
Welder	1
Junior welder	1
Junior electrician	1
Helpers	2
Clerk	1
Total	9

5.2.3 District workshop

Ownership : Private maintenance company (sole ownership or partnership), branch of a dealer workshop or state maintenance organization, division of a commercial farm or state farm.

Organization

Chart 2


Manager
or
Division Head
or
Branch Head
Administrative
Support service
Accounts
Personnel
Line maintenance
- Tractors/combines unit
- implements unit
- mobile team
Workshop
- electrical unit
- machining unit
- metal working
(forging,welding and
sheet metal) unit
General service
- type repair
- washing and
greasing
stores

Key functions : District workshop performs all preventive maintenance and repairs on agricultural equipment short of overhauling of equipment or their components. Functions of the sections include the following :

Line maintenance section : Perform all preventive maintenance or repairs on equipment (mounting, dismounting, adjusting, replacing or installing defective parts or components in the workshop or in the field).

Workshop section : Perform all minor repairs on parts or components or fabricate non-essential parts to replace parts or correct major parts by machining, welding or fabricating.

General service section : Perform washing and lubrication services on equipment, repair inner tubes and change tyres, manage fast-moving parts store and tool room.

Administrative support services : Perform the functions of accounting, including invoicing, collecting, dispersing and bookkeeping of accounts and handle all personnel matters of the staff, such as employment, employee benefits, records and relations.

Staffing

Table 8 Proposed staffing list of a district workshop

Position	Management	Administrative service	Line maintenance	Work shop	General service
Manager	1				
Secretary	1				
Typist		2			
Supervisor		1	1	1	1
Senior technician			1		
Mechanic			8		
Junior mechanic			4		
Electrician				1	
Junior electrician				1	
Welder				1	
Assistant welder				1	
Black-smith				2	
Machinist				1	
Tyre men					2
Clerk		2	1	1	2
Washing and greasing					4
Total	2	5	15	9	9
				Grand total	40

5.2.4 Regional workshop

Ownership: Private company (sole ownership or partnership or share company), main branch workshop of a dealer or state maintenance organization.

Organization : (See Chart 3)

Key functions : Plan, direct and control all preventive maintenance, repair and overhaul of agricultural equipment, short of regeneration of parts. The major functions of divisions and sections include the following:

(a) Technical service division : Perform all preventive maintenance, repair and overhaul on agricultural equipment (short of regeneration of parts) as well as manage procurement and inventory of parts and supplies.

Line maintenance section : Perform all preventive maintenance or repairs on agricultural equipment: mounting, dismounting, adjusting and replacing of parts failed or likely to fail in the workshop or in the field.

Component overhaul section : Rebuild components, such as engine gear-boxes, axles, hydraulic components, etc. through disassembly and assembly and replacement of worn out or damaged parts.

Metal working section : Perform minor repairs on parts or components through corrective measures, such as machining and welding and fabricating non-critical parts.

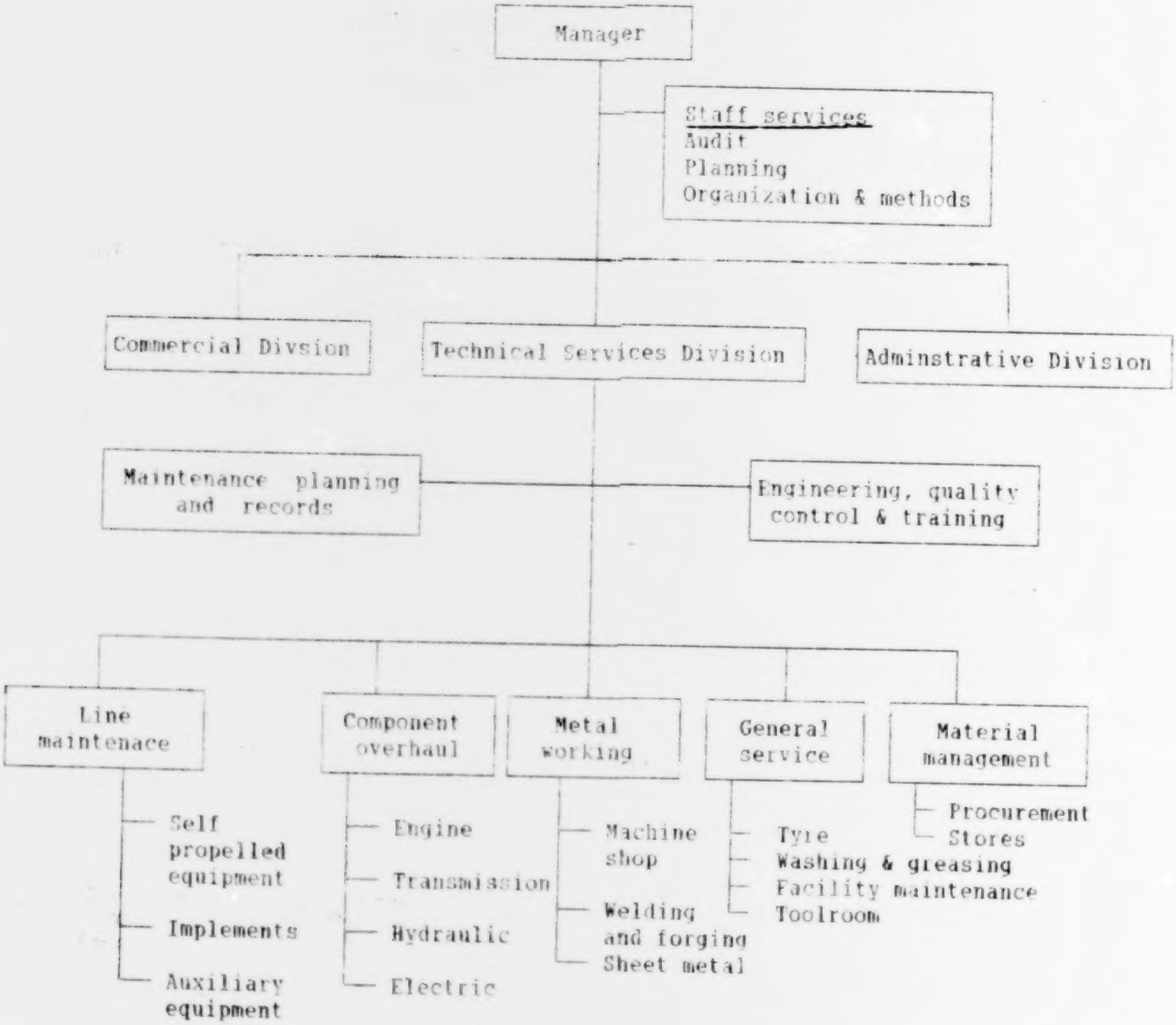
General service section : Coordinate and perform washing and lubrication services, repair tyre and tubes, maintain plant, and manage tool room and transport unit.

Material management section . Organize and manage the procurement, storage and issuance of parts, raw materials and supplies required for maintenance.

Maintenance planning and records services : Prepare and review annual, quarterl and monthly maintenance programmes, schedule preventive maintenance tasks; receive work requests, initiate work orders on maintenance; maintain records on equipment and works performed; and prepare reports to management.

Engineering, quality control and training : Perform inspection and quality assurance services on equipment on scheduled basis and after major maintenance works; operate a training unit for new maintenance personnel and up-grading the skills of existing technical personnel; and provide professional advice and assistance in purchasing, installation and maintenance of equipment and fabrication of parts.

CHART 3
Organizational Chart for Regional or Central Workshop


Manager
Staff services
Audit
Planning
Organization & methods
Commercial Divsion
Technical Services Division
Adminstrative Division
Maintenance planning and records
Engineering, quality control & training
Line maintenace
Self propelled equipment
Implements
Auxiliary equipment
Component overhaul
Engine
Transmission
Hydraulic
Electric
Metal working
Machine shop
Welding and forging
Sheet metal
General service
Tyre
Washing & greasing
Facility maintenance
Toolroom
Material management
Procurement
Stores

(b) Administrative support services : perform and manage personnel matters, such as employment, manpower development, employees' benefits, records and employee relations, and accounts, including invoicing, collection, dispersing of funds, reviewing and analyzing financial needs and sources and ensuring availability of funds.

(c) Commercial services : Perform market studies, liaising with clients, negotiating contracts and undertaking promotional work geared to increasing maintenance services to be rendered.

Staffing : Refer to Table 9.

5.2.5 Central workshop

The ownership, status and organization of a central workshop is the same as that of a regional workshop with slight expansion in key functions of the metal working section. These include regeneration and fabrication of parts for repeated usage or urgent needs.

5.3 Management system

Management systems help to simplify work, streamline channels of communication, provide uniform system enabling functions to be properly monitored and through recording and reporting enable management to evaluate performance. Management systems could vary depending on the overall objectives of the institution to be managed. With regard to maintenance organizations, the following key management systems are considered relevant:

- Manpower development
- Maintenance management
- Customer relations
- Material management

Management systems are normally prepared in the forms of manuals where overall policies and working procedures are outlined. As it is not possible to give details of these systems in this publication the presentation, of necessity, had to be limited.

5.3.1 Manpower development

Manpower development system helps to motivate workers to take new challenges or additional work or up-grade the quality of services. It embraces a system of job classification ensuring career development within the institution and the training of personnel to enable them take more responsibility. The following are some suggestions for classification, training and skill up-grading systems that should form part of an overall manpower development system.

Classification: The following classification of technical personnel of a maintenance organization is proposed.

Junior technician : New entry with formal education from a recognized technical institution working under the supervision of a higher level technician or performing light maintenance tasks on his own.

Technician : A technician with some years of working experience in the field of specialization and certified as capable to satisfactorily perform all routine maintenance activities on his own.

Senior technician : A technician with some years of working experience in the field of specialization and certified to satisfactorily perform all routine and complex maintenance jobs.

Lead technician :A senior technician with basic training in supervisory function and certified to be capable to lead a team of technicians.

Supervisor/Foremen : A lead technician or senior technician with supervisory training and experience certified to be able to lead several teams of technicians.

Up-grading

Technicians from one level should be able to undertake more responsibilities or occupy the next higher level if they are proved to have acquired the necessary skills provided there are vacant positions.The institution should also develop a procedure whereby individuals are able to up-grade their skills and ascertain their qualifications. The following is a typical system that can be employed:

- Requirements are first set for each skill level.
- Technicians are given opportunity to take skill up-grading training.
- Those who have successfully completed training are given opportunity to sit for a qualifying test.
- Those who have successfully passed are allowed to compete for openings at the next level.

New entrees : A system of taking in apprentices should be instituted.Orientation and familiarization courses on specializes machines should be given to new entrees during the period of apprenticeship. Only apprentices who have successfully acquires skills should be given employment.

Table 9 : Proposed staffing for regional and central workshops

Position	Management	Administration	Technical service	Commercial	Other
Manager	1				
Secretary	1				
Division head	1	1	1	1	
Secretary/typist	1	1	1	1	1
Typist			1	1	1
Senior expert				1	3
Expert		2	2a/	1	
Junior expert		3	2	1	3
Senior clerk		2	3	1	
Clerk		4	3		
Supervisor			4		
Senior mechanic			7		
Mechanic			20		
Junior mechanic			17		
Senior			2		
Electrician			6		
Junior electrician			8		

a/ Engineers.

Table 9 : Proposed staffing for regional and central workshops (Cont'd)

Position	Management	Administrative	Technical servic.	Commercial	Other
Senior machinist			1(3)		
Machinist			3(6)		
Junior machinist			2(4)b/		
Senior welder			1(2)		
Welder			3(6)		
Black-smith			4(6)		
Washing and greasing			4		
Helper			10		
Senior carpenter			1		
Carpenter			3		
Junior carpenter			2		
Total	4	14	111	6	8
				Total	143/156

b/ For central workshop.

5.3.2 Maintenance management

Maintenance management systems are elaborations of guidelines on :

- Maintenance policies,
- Planning, estimating and scheduling maintenance works,
- Handling maintenance works,
- Costing maintenance jobs,
- Recording and reporting maintenance activities.

Maintenance policies : Agricultural equipment maintenance organizations should adapt the policy of performing on basis of preventive maintenance programmes. Preventive maintenanc on equipment should be carried out regularly following planned schedules. Schedules based on hours worked may be difficult to implement. In view of this, schedules based on the following time intervals are proposed:

- Servicing : daily, weekly and monthly.
- Inspection : daily, weekly, monthly and quarterly.
- Preventive maintenance : weekly, monthly, quarterly, yearly and bi-yearly.
- Overhauls : Bi-yearly, every four years (depending on equipment).

Daily servicing and inspection should be the responsibility of the equipment operator where the complexity of the machine and intensity of work permits, otherwise all daily, weekly, monthly, quarterly and yearly inspections, services, and preventive maintenance need to be performed by technicians. Weekly scheduled maintenance activities may also be performed in the field. Overhauls should be done at regional or central workshops.

Where maintenance institutions are organized for other users, instituting preventive maintenance may be difficult. In such a case, a system whereby users sign contracts for preventive maintenance should be encouraged.

Planning, estimating and scheduling maintenance work

In order to enforce planned maintenance as well as plan estimate and schedule work, a complete inventory of equipment should be made and a system by which each equipment is identified with code need to be established. A record (HISTORY CARD) should be maintained on each equipment in which all particulars of the equipment and maintenance performed are recorded. A typical form which can be used for this purpose (Form 1) is included in Annex I.

To ensure the optimum use of resources, namely labour, machine, materials and facilities, maintenance work (preventive or otherwise) should be initiated well in advance. Based on equipment inventory and maintenance levels and frequencies recommended for each type of equipment on annual and quarterly basis, estimates of tentative work plan need to be worked out. On the basis of such a plan estimates for labour, parts, machine time and working space should be made; and work schedules on monthly, weekly and daily basis elaborated indicating the type of the equipment and level of maintenance. Typical forms that can be used for this purpose are shown in Forms 2, 3 and 4.

Work handling

Whether the work done is as a result of preventive maintenance programme or other reasons all work done should be identified, monitored and controlled. To this end, a system of work authorization and control should be adopted, the former consisting of two parts, a work request and a work order.

Work request is a formal document specifying the type of maintenance required. It is to be filled by equipment user. It can be a single request for a single job or a maintenance agreement for a preventive maintenance programme.

A work order is a formal internal document authorizing the execution of the requested job and is to be used to record all activities performed and inputs used. Work orders are the basic source document for a management information system. Typical work request and work order forms (Forms 5 and 6) are attached.

It is advisable that all works requested by external bodies be verified by qualified inspectors before work is initiated.

Costing jobs

Costs of executing a maintenance job consist of labour cost, material cost (part and component), over heads and profit margin.

Labour costs : Costing labour can be made following two systems. The first and better system, specifically recommended for preventive maintenance tasks, is a flat rate for each level and type of maintenance. Estimates of labour hours by type and level of maintenance should be fixed at the beginning. The number of hours worked multiplied by the hourly rate give total cost. Such a system is preferred by equipment users as they are aware of the expected costs of maintenance ahead of time.

The second system is costing for actual labour hours expended. Hourly labour costs can be calculated as follows for each work center or for the whole organization. However, as use of different rates for different work centers could be complex to implement use of a single labour cost figure is recommended.

Total salaries and benefits of technical services = C_T

Total revenue generating labour hours per year = H_T

Total number of employees = L_T

Chargeable labour cost per hour = L_H

$$L_H = \frac{C_T}{H_T \times L_T}$$

Total revenue generating labour hours is calculated as total available labour hours per year of service generated by employees less estimated non-productive labour hours.

Material cost should be charged on the basis of costs of materials consumed plus inventory carrying costs and margin. Inventory carrying costs are normally regulated by low.

Overhead costs include those related to management and facilities. Management overhead costs are normally fixed as percentage of total labour and material costs (5-10 per cent). Facility overhead costs are calculated on basis of total annual depreciation costs divided by revenue generating labour hours multiplied by chargeable labour hours.

Profit margins are set at 25-30 per cent of total costs (labour, material and overhead) as per above.

Charging separately for transport time for mobile maintenance should be avoided, wherever possible,as it tends to discourage farmers located away from workshop from calling for service. With planned maintenance, it is possible to reduce transport costs and these costs should be built-in into hourly labour cost.

Recording and reporting of maintenance activities

Works performed in a maintenance organization need to be compared against plan and the results of such comparison should be used to make more realistic plans in future and institute improvement programmes. Records on labour and material inputs have to be made, processed and reported to inform management of the performance of the maintenance units. The following records should form part of recording and reporting systems :

- Labour input.
- Material input.
- Work requests received and completed.

These records should be controlled through work authorization documents, such as work request, work orders and history cards. The following reports should be generated :

Work performed (completed) : Covering total work requests received, carried over, delayed, completed on time should be compiled for each work station on a weekly, monthly, and yearly basis. A typical form which can be used for this purpose is Form 7

Labour utilization records on the basis of same frequency as for work completed, including reports on available labour hours, planned labour utilization, actual labour utilized, overtimes performed and variances should be compiled. A typical form for recording and reporting is Form 8.

Material utilization records (value by item) should be reported on the same basis as those for the other two reports.

Records should be accumulated for individual equipment for monitoring performance and comparing costs between different makes, models and users. Repetitive failures should be drawn to the attention of engineering or R + D departments and/or equipment suppliers for investigation.

5.3.3 Customer relations

The system of customer relations is different depending on whether the maintenance establishment is organized for captive use or for use by others. Even in the case of captive use, there must be a separation between equipment users and maintenance units. The following working system need to be established for maintenance establishments organized to serve others.

- Inventory of all clients within the market area must be maintained.
- Clients must be made aware of the range of services available.
- Training in the proper use of equipment must regularly be given.
- A single contact point with the client should be maintained.
- Clients should be encouraged to opt for contracts for preventive maintenance.
- Regular visits by commercial technical personnel to customers should be made and assistance provided in solving farmers problems.
- If possible,stand-by equipment should be maintained by maintenance establishments for critical time when customer's equipment is down for long maintenance.

5.3.4 Material management

Material management system consist of procurement and inventory management. Materials to be stocked in agricultural equipment maintenance institutions comprise spare parts, raw materials and supplies.

Procurement : Procurement covers the process of establishing needs,identifying sources of supply, ordering the required materials and following up until materials are delivered at users premises. The system of procurement depends on whether materials are procured locally or imported. Needs are determined by initial order for new stock or repeated orders for replenishment of existing stock.

New stock :Need for new stock should be based on list of spares recommended by suppliers and verfied by a provisioning team composed of store , maintenance and engineering personnel.

Replenishment of stock should be on basis of perpetual inventory control following reorder levels and reorder quantities. A simple technique, which takes into consideration the long process of foreign exchange acquisition, is to review, on a quarterly basis, all stock and bring stock level to cover consumption during lead time.

Procurement personnel should maintain a directory of all suppliers and continue to identify new suppliers and products. New products however need to undergo an evaluation process before they are considered for bulk purchase.

Procurement should be on basis of purchase requisition and purchase orders. A system by which non-fast moving items are returned to supplier should be negotiated. Typical forms that can be used for this purpose are Forms 8, 9 and 10.

Inventory management : Inventory management covers the functions of receiving, issuing, stocking and inventory control.

Receiving : Each item received at store should be inspected to confirm its identify and quantity. Each entry should be made through a receiving document (Form 11) and registered on inventory control card.

Storage : Location in stores should be such that small and fast-moving items are stocked close to issue points and slow and heavier items further away. Perishable, precious or hazardous materials should be stocked separately.

Location : Systems should be instituted for easy identification. Items suseptible to corrosion should be packed in plastic bags.

Issuing : Issuing should be on first come first service basis. It should be done on basis of issue document (Form 12) and registered on inventory control card. As much as possible, items should be issued on the basis of first in first out basis. Farming units due to either shortage of working capital or for fear of carrying dead stock refrain from buying adequate quantities of essential parts. This sometime means facing avoidable down time for lack of simple easily replaceable part during critical operational period. Therefore, parts distribution or sales organs should encourage farming units to carry essential spares during operational seasons on loan basis to be returned later if unused.

Inventory control : All stock items should be monitored through a prepetual stores (cardex system) or computerized inventory system. All entries, issues and orders should be entered in inventory control cards (Form 13). Each stock item should be monitored separately. In case of large inventory physical inventory can be made on continuous basis such that each item is controlled once a year otherwise total physical count should be made once a year. Where continuous inventory is applied, total physical inventory need to be made once in five years. Coloured plastic sheets can be used to segregate fast-moving from slow-moving items. Dead stock should be regularly disposed of.

5.4 Financial requirements

Financial requirements for a maintenance improvement programme can be grouped into two categories : capital investment and working capital. Each of these have foreign exchange component and local currency component.

Capital investment needs consist of funds for building infrastructure and for the purchase and installation of equipment. Working capital is financial means required to operate the maintenance programme. It includes provisions for materials and supplies, wages and salaries, utilities and cash. For the purpose of this publication financial provision for three months is considered adequate.

Estimates of both capital investment and working capital requirements are given for the different categories of maintenance institutions. The estimates in Table 10 show average costs for average sized facilities.

Table 10 : Estimates of investment requirement for the different levels of maintenance facilities for agricultural equipment (US$)

Description	Artisanal		Basic service station		District workshop		Regional workshop		Central workshop	
	Total	Foreign	Total	Foreign	Total	Foreign	Total	Foreign	Total	Foreign
Fixed capital										
- Land	-	-	-	-	-	-	-	-	-	-
- Building	1,500	-	15,000	2,000	250,000	50,000	600,000	170,000	870,000	260,000
Equipment										
- Office	100	-	250	-	600	150	2,500	750	15,000	10,000
- Workshop	600	400	15,000	9,000	200,000	160,000	800,000	640,000	2,500,000	2,000,000
Utilities										
- Water	-	-	500	300	1,500	6,000	30,000	12,000	45,000	18,000
- Power	150 *	-	300		30,000	24,000	60,000	48,000	100,000	80,000
- Compressed air	-	-	3,000	2,700	10,000	9,000	25,000	20,000	30,000	25,000
Transport equipment	-	-	25,000	15,000	40,000	30,000	180,000	110,000	200,000	120,000
Parts inventory	-	-	5,000	3,000	50,000	40,000	500,000	350,000	800,000	560,000
Sub-total	2,350	400	64,550	32,000	595,600	319,150	2,197,500	1,350,750	4,560,000	3,073,000
Contingency= 15%	353	60	9,680	4,800	89,340	47,870	329,625	202,610	684,000	460,550
Total	2,703	469	74,230	36,800	684,940	367,020	2,527,125	1,553,360	5,244,000	3,533,950
Working capital										
Direct material	864		3,800		23,040		114,480		222,900	
Direct labor	1,050		4,800		28,000		175,000		200,000	
- Sundries**	150		1,000		5,000		20,000		25,000	
Sub-total	2,054		9,600		48,040		309,530		447,900	
Contin.20%	412		1,920		9,608		61,906		89,580	
Total	2,476		11,520		57,648		371,436		537,480	

* Only if power is available.

** Includes cost of utilities, fees, charges, promotional expenses, etc.

5.5 Summary and recommendations

The present level of technologies employed in most parts of Africa is much to be desired. Note only low level of technologies are in use but also the prospect for their future development is gloomy. Agricultural equipment situation in Africa is deplorable and characterized by low level of availability, utilization, high downtime and operating costs.

The low level of utilization coupled with the rising costs of equipment and their spare parts has made the feasibility of using higher technologies questionable. In fact, many African countries are in the process of opting for lower level of technologies, such as animal power technologies in lieu of tractorization.

Among the key factors which have resulted in such a deplorable state of affairs is the inability to perform quality maintenance on equipment for lack of the required maintenance facilities, skilled manpower and appropriate maintenance systems.

The building of improved capabilities for the maintenance of agricultural equipment not only ensure better availability, higher utilization, lower downtime and operating costs but will also serve as basis for future agricultural equipment manufacturing industry

It is important and timely for African countries to take positive steps towards developing improved maintenance capabilities. Measures to be taken by African Governments for the realization of maintenance improvement programmes are presented below, in chronological order:

1. Develop mechanization policy/strategy. The development of a maintenance programme should be based on current level of mechanization taking account of future development. Building a maintenance establishment is capital intensive as well as time consuming. A sound development plan should be based on medium- and long-term objectives. Mechanization policy is an essential element for the determination of future levels of mechanization.
2. Inventorize existing farm equipment in use. Absence of reliable data is a major constraint faced by planners. Maintenance needs can be determined only if accurate information on type and quantities of equipment in use is known. The generation of such data upon which a maintenance improvement programme can be initiated is among the initial activities to be performed.

   Techniques that can be used to carry such an inventory is outlined in Section 4.1 of this publication.

3. Inventorize existing maintenance facilities. In order to establish the adequacy and appropriateness of existing maintenance facilities, inventory at national level need to be undertaken by Governments. This should enable them to identify the shortcomings of existing establishments as well as their ability to meet future needs. Procedures for undertaking such an inventory are outlined in Section 4.2.

4. Develop maintenance policy and system. Setting clearly defined policies and establishing effective management procedures and methods for maintenance is an excellent way to perform maintenance effectively and on business basis. A system by which maintenance needs can be properly identified in advance, programmed, executed and monitored is essential in undertaking a maintenance improvement programme. In particular, commitment to enforce planned preventive maintenance practices helps in improving availability of and reducing parts usage and eventual reduction in maintenance downtime. This is highly recommended. Suggestions on the scope and contents of maintenance policy and systems are outlines in Section 5.3.2.

5. Define maintenance needs. Based on equipment population and adopted maintenance policies and procedures, it is important to conduct analysis of maintenance needs (demand/supply gaps). Procedures that can be used to assess maintenance needs are outlined in Section 4.1.

6. Undertake maintenance improvement programme. Once prerequisites to undertaking a maintenance improvements programme are in place, then the following steps are suggested in realizing such a programme.

   6.1 Rationalize and strengthen existing establishments through one or a combination of the following:
      - Upgrading ;
      - Relocating ; and
      - Strengthening with manpower and equipment.

   6.2 Establish new ones.

   6.3 Develop auxillary support facilities.

Parallel to the strengthening of maintenance establishments the development of spare parts and supplies distribution net-work should be given due consideration. The installation of a computerized inventory system for spares and supplies should be explored.

Positive steps towards developing engineering industries capable of locally manufacturing critical and fast moving spares should be taken.

Training institutions for the development of maintenance personnel should be established and training programmes prepared.

Samples of Typical Forms Related to Maintenance and Material Management Systems

FORM 1: EQUIPMENT HISTORY CARD

Annex I
Page 1 of 2

Equipment I.D. No. ____________

1. Type ____________ 2. Model ____________ 3. Serial number ____________
4. Dimension ____________ 5. Weight ____________ 6. Purchase value ____________
7. Year of manufacture ____ 8. Purchase date ____ 9. Date put to use ____________
10. Manufacturer ____________ 11. Supplier ____________ 12. Local agent ____________
13. Supplier's Address ____________
14. Major components ____________ 15. Equipment & assignment ____________

	Type	Model	Serial No.
14.1			
14.2			
14.3			
14.4			

	Dept/area	Date in	Date out
15.1			
15.2			
15.3			
15.4			

16. Maintenance and operating costs (in local currency)

I/No	Year	Total hrs per milage	Output		Costs							Total costs
					Operating costs				Maintenace costs			
			Task code	Units	Lub	Fuel	Operator	Total	Labour	Materials	Total	

Prepared by ____________
Name & signature

Approved by ____________
Name & signature

Checked by ____________
Name & signature

FORM 1: EQUIPMENT HISTORY CARD (continued)

17 Major changes record

I/No	Date	Description	Costs			Milage or hours	Remarks
			Labour	Material	Total		

FORM 2: ANNUAL MAINTENANCE, FABRICATION & INSTALLATION WORK PLAN

YEAR ______

<table>
<tr><th rowspan="3">Ident No</th><th rowspan="3">Eqp Code</th><th rowspan="3">Units No</th><th colspan="7">Service frequency time</th><th colspan="9">Inspection frequency time</th><th colspan="9">Preventive maintenance frequency time</th><th colspan="3">Break down</th><th colspan="3">Over haul</th><th colspan="3">Instl</th><th colspan="3">Fabrication</th><th colspan="2">Grand total</th></tr>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th>Ttl</th><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th>Ttl</th><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th><th colspan="2">4</th><th>Ttl</th><th colspan="3">TM</th><th colspan="3">TM</th><th colspan="3">TM</th><th colspan="3">TM</th><th></th><th></th></tr>
<tr><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>F</th><th>I-E</th><th>I-E</th><th>F</th><th>I</th><th>E</th><th>F</th><th>I</th><th>E</th><th>F</th><th>I</th><th>E</th><th>F</th><th>I</th><th>E</th><th>I-E</th><th>T</th></tr>
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</table>

I: Time for inhouse
E: Time for external

1: Indicates weekly frequency
2: Indicates monthly frequency
3: Indicates quarterly frequency
4: Indicates yearly frequency

Ttl: Total
Instl: Installation
T: Total time
F: Frequency

FORM 3: QUARTERLY MAINTENANCE, FABRICATION & INSTALLATION MASTER WORK SCHEDULE

Annex I

Year _________ Quarter ______

I/No	Equipment category code	Month														Month														Month													
		Units due														Units due														Units due													
		Inspection				Service			Preventive				Overhaul	Fabrication	Installation	Inspection				Service			Preventive				Overhaul	Fabrication	Installation	Inspection				Service			Preventive				Overhaul	Fabrication	Installation
		1	2	3	4	1	2	3	1	2	3	4				1	2	3	4	1	2	3	1	2	3	4				1	2	3	4	1	2	3	1	2	3	4			

1: Weekly 2: Monthly 3: Quarterly 4: Yearly

FORM 4: MONTHLY MAINTENACE WORK SCHEDULE BY EQUIPNENT

Annex I

Equipment Id. No ________

Period ____________

No	Preventive Maintenace		Week 1							Week 2							Week 3							Week 4						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1	I	Weekly																												
2	n	Monthly																												
3	s	Quarterly																												
4	p	Yearly																												
1	S	Weekly																												
2	e	Monthly																												
3	r	Quarterly																												
4	v	Yearly																												
1	P M	Weekly																												
2	r n	Monthly																												
3	e t	Quarterly																												
4	v n	Yearly																												
0		Overhaul																												

Insp: Inspection; Serv: Service; Prev. Mntn: Preventive maintenance

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FORM 5: WORK REQUEST SLIP

Annex I

1. Equipment Id. No ______ No __________

2. Requested by ____________________ ____________________ ________
Name & signature Enterprise/Department Date

3. Approved by ____________________ ____________________ ________
Name & signature Position Date

4. Type of work requested

4.1 Maintenace [ ]
4.2 Fabrication [ ]
4.3 Installation [ ]

5. Priority [ ]

6. Dates & references:

	Dates	Referecne
6.1 Received at p/c	________	________
6.2 Received at eng/ins	________	EO ________
6.3 Received at p/c	________	________
6.4 Received at w/c	________	WO ________
6.5 Work completed	________	________
6.6 Delivered to client	________	INV ________

7.

I/No	Description of work requested	Task performed	Cost summary	
			Labour Spares Consumables Overhead	
			Total	

Planning & control ____________ Client's signature for receipt ____________
Name & signature

Prepared by ____________ Approved by ____________
Name & signature Name & signature

Checked by ____________
Name & signature

P/c: Planning control; Eng/ins: Engineering inspection; W/C: Work centre;
W.O: Work Order; INV: Invoice; EO: Engineering order

FORM 6: WORK ORDER

1. From (dept/section) ________ 2. Signed by ________ 3. Date issued ____________
4. To (dept/section) ________ 5. Date received ________ 6. Work requested by ______
7. Work request No ________ 8. Date requested ________ 9. Type of work requested
10. Equipment I.D ________ 11. Priority ________ 9.1 Maintenance [ ]
12. Date started ________ 13. Date completed ________ 9.2 Installation [ ]
14. Details of work 9.3 Fabrication [ ]
15. Cost summary (in local currency)

I/No	Requested	Work done

Title	Estimate	Actual
(a) Labour		
(b) Parts		
(c) Consumables		
(d) Overheads		
TOTAL		

Supervised by ____________________
Name & signature

Inspected by ____________________
Name & signature

Foreman ____________________
Name & signature

Received by ____________________
Name & signature

FORM 6: WORK ORDER (continued)

23. Actual cost breakdown for labour & materials (local currency)

I / No.	Name	Actual labour (Time)						Actual materials		
		Date	Start	Stop	Hours	Rate	Total	Issue voucher No	Line item	Value

Prepared by ____________________
Name & signature

Checked by ____________________
Name & signature

Annex I
Page 1 of 2

FORM 7: DAILY WORK CONTROL SHEET

Section ______________________ Date ____________

I / No.	Work order No	Date started		Date completed		Labour time	
		Planned	Actual	Planned	Actual	Planned	Actual
					Total		

Prepared by ______________________
Name & signature

FORM 7: DETAILS OF DAILY WORK CONTROLS SHEET

Annex I
Page 2 of 2

I / No	Nature of work order	Inspection					Service				Preventive					BD	IN	FB	T
		W	M	Q	Y	T	W	M	Q	T	W	M	Q	Y	T				
1	Backlog																		
2	Newly received																		
3	Scheduled for completion																		
4	Actual completed																		
5	Carried over																		
6	Planned labour																		
7	Actual costs																		
	- Labour																		
	- Material																		
	- Over head																		
	- Total cost																		

W: Weekly
M: Monthly
Q: Quarterly
Y: Yearly
T: Total
BD: Break down
IN: Installation
FB: Fabrication
T: Total

FORM 8: WEEKLY LABOUR UTILIZATION REPORT

Location ___________

Week _____

No.	D a	Planned hours						Actual availalable hours						Actual utilized hours						Per cent Planned	Per cent available
		L	S	T	J	H	Tot	L	S	T	J	H	Tot	L	S	T	J	H	Tot		
1	Monday																				
2	Tuesday																				
3	Wednesday																				
4	Thursday																				
5	Friday																				
6	Saturday																				
7	Sunday																				
Total																					

L: Lead technician
S: Senior technician
T: Technician

J: Junior technician
H: Helper
Tot: Total

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FORM 9: PURCHASE REQUISITIONS

Annex I

Serial No ____________ Date ____________
1. Requested by (Name) ____________ Section ____________
2. Approved by (Name) ____________ Position ____________
3. Category
   3.1 Stock item
      Parts [ ]
      Supplies [ ]
      Consumables [ ]
      Tools & catalogues [ ]
   3.2 Non-stock item
      Fixed assets [ ]
      Expendables [ ]
4. Priority
   4.1 Urgent [ ]
   4.2 Routine [ ]

I/No	Manufacturer's part No.	Description	Qty	Unit of measure	Estimated price (in local currency)	
					Unit	Total

Parts required for ____________
Previous supplier ____________ Purchase order No. ____________

Purchasing action ____________
Received on ____________ Verified by ____________
Name & signature

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FORM 1A: PURCHASE ORDER Annex I

P.O. ________
Date ________

To ____________________ Ship to ____________________

Terms: Shipment: Air/surface ________ FOB/C&F/CIF ________
Payment ____________________
Ref: Your offer ____________________

I/No	Manufacturer's part No.	Description	Unit of measure	Quantity	Unit price	Total price
					Total	
					Charges	
					G. Tot	

Please supply the goods shown above at the prices stated, subject to the conditions herein set out and to the instructions and conditions mentioned on the reverse side of this order (to be formulated by the purchaser). N.B. Kindly return by air mail the attached **second** copy of this order duly signed by you as confirmation of same. The instruction on reverse side forms part of this order.

FORM 11: GOODS RECEIVING REPORT

Annex I

Serial No. ______________
1. P. O. No. ______________ 2. Invoice No. ______________ 3. Date ______________
4. Supplier ______________ 5. Shipment AWB/B/L ______________ 6. Received on ______________
7. Coefficient cost ______________ 8. Coefficient sales ______________ 9. Entered by ______________

I / No	Code Number	Location	Description	Quantity			Cost			Sales price in local curr.	
				Order	Invoice	Recvd	Ex-factory in foreign curr.	Unit landed cost in loc. curr.	Total landed cost in local curr.	Unit	Total
							Total				

Received by ______________ Date ________
Checked by ______________ Date ________
Entered by ______________ Date ________
Descrepancy report ______________

AWB/B/L: Airwaybill/bill of lading. Coefficient: factor which when multiplied by **ex-factory prices gives landed cost and sales price.**

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Annex I

FORM 12: MATERIAL REQUISITION

Serial No ________________

1. Requested by ____________________ Section __________________ Date ____________________

Name

2. Approved by ____________________ Dept/Section ____________ Date ____________________

Name

3. Requested for:

3.1 Own use ☐ 3.2 Client ☐ 3.3 Direct sales ☐ 3.4 Transfer ☐

I/No	Manufacturer Part No.	Code No.	Description	Quantity/number			Local currency		Location
				Requested	In stock	For issue	Unit price	Total	

Stores

Approved by ____________________ Date ____________

Entered by ____________________ Date ____________

Issued by ____________________ Date ____________

Issue voucher/invoice No. ____________

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Annex I

FORM 13: INVENTORY CONTROL CARD

1. Minimum stock level ____________

2. Unit of measure ____________

Date	Ref No	Rcvd	Issued	Balance	In local currency		Date	Ref No	Rcvd	Issued	In local currency	
					Averg. cost	Averg. sales price					Averg. cost	Sales price

Code No ____________

Description ____________

Manufacturer part No. ____________

Interchangeable No ____________

Agricultural Equipment Maintenance

Improvement Programme

Survey of Existing Maintenance Institution

Questionnaire for Data Collection

1. IDENTIFICATION

1.1 Name ____________________

1.2 Date start of operations ____________________

Address: City/Town/Village ____________
Country ____________
P. O. Box ____________
Telephone ____________
Telex ____________

1.3 Ownership:
Private: Local ☐ Foreign ☐ Mixed ☐
Multi-national: African ☐ Non-African ☐ Mixed ☐

Public ☐ State farm ☐
Maintenance institution ☐

1.4 Adminstrative service to: Own fleet ☐ Others ☐ Both ☐

1.5 Contact person: Name ____________________ Telephone ______

2. INFRASTRUCTURE

2.1 Land total area (sq m) ________ Built-up area (sq m) ________

2.2 Buildings:
Total covered area (sq m) ______ Open shed (sq m) ____________
Enclosed (sq m) ____________ Type of construction:
Permanent ☐ Semi-permanent ☐ Temporary ☐

2.3 Equipment installed (use Table A-1)

3. ORGANIZATION

3.1 Organizational status:
Private company ☐ Public enteprise ☐ Mixed ☐

3.2 Organization chart (Attach)

3.3 Manpower (number):
Management ____________
Supervisors ____________
Senior technicians ______
Technicians
Junior techicians ______

Helpers ____________
Clerical staff ____________
Cleaners ____________
Guards ____________
Drivers ____________
Messengers ____________

4. UTILITIES

Water: (capacity in cu m/day) ____________________
(consumption in cu m/day) ________________
Power: (capacity in KW) ____________________________
(Consuption in KWH/day) ________________
Compressed air: (capacity in lts/sec) ____________
Fuel: type __________ tank capacity (in litres) ______ No of pumps __
type __________ tank capacity (in litres) ______ No of pumps __
type __________ tank capacity (in litres) ______ No of pumps __

5. SUPPORT SERVICES

Stock spare parts: total No. of line items _____ value ____________
Supplies: total No. of line items ______________ value ____________
Usage: parts No. of line items/year ___________ value/year ________
Supplies No.of line items/year ___________________ value/year ________

6. FINANCE (US$)

Fixed capital investment ______________________________
Working capital investment ____________________________
- Wages & salaries _________________________________
- Consumables (parts, supplies, raw materials) ______
- Sundries (utilities, fees, chrges, etc.)

Revenue (current year 19__) ____________________________
- Maintenance serices ______________________________
- Sales of parts ___________________________________
- Others ____

Profit - Gross (before tax) ____________________________

7. SERVICE CATEGORY AND VOLUME
(in number of units serviced)

Type of sevice	Year 1	Year 2	Year 3
- Preventive maintenance			
- Break-down maintenance			
- Repair			
- Fabrication			
- Regeneration (reworked)			
- Overhauls			

8. EQUIPMENT TYPE AND NUMBER HANDLED

Type	Year 1	Year 2	Year 3
- Hand tools			
- Animal drawn implements			
- Self propelled machines			
- Implements for powered equipment			
- Components			
. Engines			
. Electrical parts			
. Transmissions			

9. TARGET USERS (Per cent)

- Peasants ____________
- Commercial farmers ____________
- State farms ____________
- Own fleet ____________

Total 100.00

TABLE A-1: DETAILS OF MACHINES & EQUIPMENT INSTALLED IN THE INSTITUTION

No	Machine/equipment	Specification	Make	Quantity	Year of installation	Location (shop)	Present condition

ANNEX III

Profile of
Power Equipment Limited
Lusaka, Zambia

1. Location : Power Equipment Limited (PEL) is an agricultural equipment dealer, primarily dealing with Massey Ferguson equipment. Its headquarters is in Lusaka (Cairo Road). It has a branch office and service station in Kitwae, North Zambia, and service outlet at Mazabuka and dealer service at Mukushi and Kussamia.

2. Ownership and management : A private limited company owned by Zambians. It is managed by a General Manager, assisted by three senior managers, a chief accountant, a sales manager and a technical manager.

3. Facilities

Land : Its headquarter facilities have a total land area of 2,582 m^2 of which over 50 per cent is covered. Of the covered area, about 200 m^2 is allocated for workshop.

Workshop equipment : Workshop equipment consist of hand tools, measuring instruments and material handling equipment. Machine shop equipment are non-functional. Other equipment consist of hydraulic hose fitting machine, universal electrical machine tester, and paint booth with spray painting accessories. Details of equipment is not available.

4. Support facilities

The workshop has a parts store with over 19,000 items in stock. Parts are for both sales to customers and own use. Availability is estimated at 70 per cent. The firm, due to inadequate foreign exchange allocation, is also engaged in recycling used spare parts and sub-contracts local industries for the manufacture of some parts. Other support facilities include a fuel depot.

5. Manpower : The company has a total of 60 maintenance personnel at headquarters.

6. Maintenance service programme

Customers : The customers consist of :

- large agro-industrial projects (about 10 per cent)
- large scale commercial farmers (about 60 per cent)
- peasants/emergent farmers (about 50 per cent)

It is estimated that the firm caters for 50 per cent of the maintenance demand of the above customers and of the balance 50 per cent, private workshops handle 20 per cent while user workshops cater for 30 per cent.

Type of maintenance service rendered : The services extended include :

- Break-down maintenance : Users do not come for preventive maintenance and mechanism for this does not exist.
- ROC 1/: A rebuilding and/or up-grading tractors to predetermined specifications.
- Rehabilitation programme : Rehabilitation programme is a monitored repair programme to replace essential parts and bring back tractors to working condition.

1/ ROC Terminology used by

- Component overhaul services : Including engine and electrical components overhaul.

- Fitting of hydraulic hoses.

The company presently is testing a prototype of an adopted MF tractor for possible local assembly.

Training services

- In-service training of users' technicians for a period of upto three months, (specially for those whose tractors have undergone **an ROC maintenance**) with training provided free and accommodation born by users.

Maintenance capabilities and achievements

- Plan and actual number of light repairs performed are not known.
- Planned capacity for ROC or rehabilitation programmes is 50 tractors per year. Present achievement is 30 tractors per year.

Mode of delivery of service and charges

- In workshop, services at the central workshop and branch workshops are charged on the basis of hourly labour rates of 35 K (10K = 1.0 US$) and spare parts at retail prices. Discounts for users with large fleets are possible.

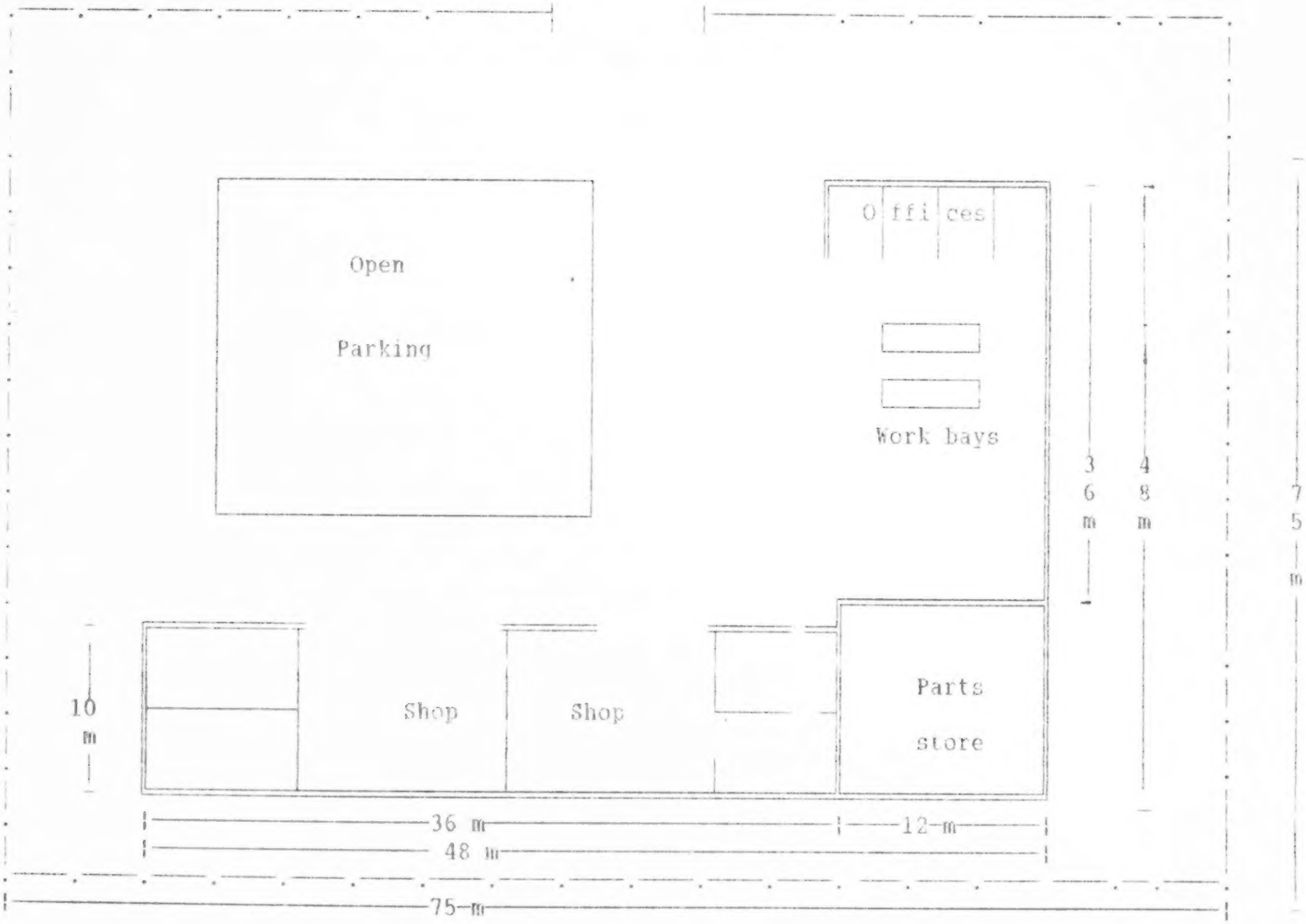
- Mobile service : Two mobile teams deliver break-down maintenance services on request. Charges are at 85 K per labour plus travel cost based on mileage. Parts are charged at retail prices.

8. Major constraints and shortcomings

- The workshop is located in an urban area, far from most farmers, and facilities are not utilized for light maintenance.
- Mobile service is too costly to attract users.
- Very low level of investment on workshop equipment; most activities are manual and depend heavily on external specialize workshops.
- The primary objective of the firm is sales of equipment. There is, therefore, less emphasis on maintenance. Because of their high returns, concentration is on ROC and rehabilitation.
- Current shortage of spares is increasingly affecting availability of spares.
- Because of lack of skilled manpower, the firm had until recently, to rely on expatriate experts for the ROC and rehabilitation programmes.

Layout of a SIROFTA farm

Workshop


Open
Parking
Offices
Work bays
36 m
48 m
75 m
10 m
Shop
Shop
Parts
store
36 m
12 m
48 m
75 m

ANNEX IV

Profile of
Sirofta Farm Workshop
Bale, Ethiopia

1. Location

Sirofta farm workshop is a maintenance unit of Sirofta State Farm. It is located in Bale Region, Genale Awraja (district), Dodola Wereda (locality) on farm site some 80 km east of Shashamene.

2. Ownership and management

The workshop is owned by Bale Agricultural Development Enterprise, a subsidiary of the Southern Agricultural Development Corporation. The workshop is managed by a maintenance section head who is responsible directly to the farm manager. Technical guidance is provided by the technical departments of the Enterprise and the Corporation.

3. Facilities

Site: The workshop has a total land area of about 6,000m^2 of which about 4,500 m^2 is built-up area.

Building : The workshop building is an 'L' shaped partly open shade building. It has a total area of 936 m^2. The workshop whose layout is attached has the following shops and work areas :

- work bays with pit	4
- work bay without pit	1
- work bays for implements repair	2
- welding shop	1
- electrical repair shop	1
- oil and grease store	1
- parts store	1
- offices	

Equipment and tools : the main workshop equipment and tools consist of :

- Electrical hand grinder	2	- Bench grinder	1
- Tap and die set	1	- Rim wrench	2
- Air compressor	1	- Torque wrench	1
- Oxygen bottle and tube	1	- Anvil	2
- Trailed mobile workshop	1	- Chain hoist	1
- Battery charger	2	- Hydro meter	1
- Table and vice	2	- Metal shear	1
- Hydraulic press	1	- Tool set	24
- Injector tester	1	- Oil filler pump	1
- Petrol electric generator	1	- Sets of tools for mechanics, welders, pipe fitters and electricians.	
- Sodering iron	1		
		- Set of wrenches of	

Utilities : Water - own bore hole
Power - diesel generator (75 Kw)

4. Support facilities

The workshop has a spare parts store with over 3,300 line items of which nearly 45 per cent are combine harvester parts and over 35 per cent tractor parts, the rest being parts for implements and vehicles.

Space parts are procured from the central store of the parastatal responsible for the import and distribution of agricultural equipment. Charging is done at purchase price.

5. Manpower

The workshop has 38 technical personnel categorized as follows :

- Maintenance head	1
- Mechani	6
- Junior mechanic	19
- Electrician	3
- Junior electrician	2
- Welder	2
- Junior welder	2
- Tyre men	3
Total	38

6. Investment

Fixed capital : Not known.

Working capital : 233,790 Birr

7. Maintenance service programme

The customer of the maintenance services is own mechanization unit whose machinery population is made up of :

- Tractors	93 of which 41 operational
- Combine harvesters	24 of which 19 operational
- Trailors	36 of which 36 operational
- Implements	146 of which 97 operational

Type of maintenance services rendered :

- Break-down maintenance (primary activity)
- Preventive maintenance (not fully enforced)
- Light repairs (mechanical and electrical)
- Servicing
- Welding and forging

Training services

Maintenance capabilities and achievements

- Planned capacity is based on all preventive maintenance and minor repairs for an average of two tractors and associated equipment per day.

- Performance is not known as no record of maintenance activities are systematically compiled. However the low serviceability of machinery as per above indicate poor performance.

Mode of delivery of service and charges

- Maintenance work is done on the basis of requests from the mechanizat unit. Cost of labour is not charged. However, spares used are costec at purchase price.

9 Major constraints and shortcomings

- Absence of policy guidelines and procedures to enforce preventive maintenance practices on planned basis;

- Shortage of spares, partly due to changing makes of equipment;

- Absence of incentive system for technicians and operators; and

- System of costing maintenance does not permit evaluation of effectiveness.

- Mould-board ploughs)
- Ridgers)
- Spike tooth harrows) used with animal power
- Duck-foot cultivators)
- Raw planters)

The present trend to use minimum tillage practices is minimizing the use of disc and mould board ploughs with powered equipment.

d) Irrigation equipment : Underground water is extensively used by commercial farmers in certain parts of the country. Surface water irrigation is limited to large-scale farms, such as sugar plantations. Equipment used consist of submersible pumps, sprinklers, water distribution pipes and centrifugal pumps. National statistics on types, makes and population is unavailable. According to dealers, the types and makes are reported to be many.

e) Post-harvest equipment: Post-harvest equipment include maize mills and those used for transport, such as ox-carts. Both equipment are available in good numbers in the rural areas.

2.3 Demand and supply situation and distribution of equipment

Demand

Current consumption of agricultural equipment has been estimated by different studies. Demand is growing partly due to the accumulation of unfulfilled demand resulting from lack of foreign exchange for imported equipment. Demand for tractors (comprising three classes) is estimated at an average of 1,000 units per year 1/ during the period 1991-1992. Tractors for hire are in demand by both commercial farmers and emergent farmers as cost of owning is rising.

Demand for farm implements, particularly ox-drawn ploughs, is expected to grow as a result of the emphasis on promoting animal traction. Annual consumption of ploughs is estimated at 13,500-15,000 units during 1988-1989 2/. Estimates for other implements is set at 4,500-5,000 units consisting of cultivators and ridgers. Demand for ox-carts is estimated at 2,000 units/annum. Figures for irrigation equipment were not available.

The supply of agricultural equipment depends on the level of technology in question. Powered machines, such as tractors, harvestors, threshers and associated implements are met through import alone. Farm implements for animal power, maize mills and ox-carts, however, are partly or fully met through local manufacture. Local manufacturing capability exist for ox-carts, oxen plough and maize mills. It is, however, handicapped by the shortage of adequate and good quality raw materials. These have affected both the quality and quantity of locally manufactured implements. Several industrial units adequately equipped and manned for the local manufacture of the above exist in Zambia. The two most significant are Northland Engineering, a private company, and Lusaka

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1/ECA, Model-Pre-Feasibility Report:Agricultural Machinery, Equipment and Tractors by HMT (International) Limited, 1988.

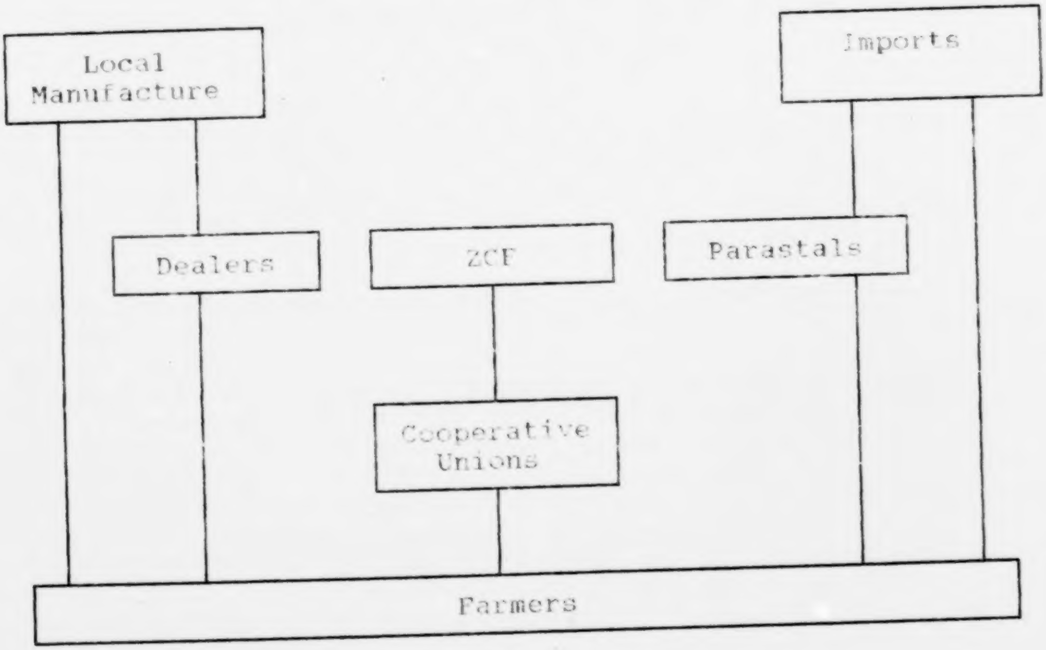
2/ Ministry of Agriculture and Land Development, Zambia.

Engineering Co. Ltd. (LEMCO), a parastatal. Northland specializies in animal drawn implements and produces complete single farrow mould board ploughs, cultivators, ridgers, maize mills and ox-carts. LEMCO partly manufactures and assembles mould board ploughs and ox-carts. Others, such as Turnins and Metals, produce maize mills and ox-carts. Eventhough local production capability exists to fully meet demand, import of these items continue :

Distribution

Distribution is done mainly through Zambian Cooperative Unions, private dealers and parastatals. These distribution channels are better explained by the following diagram :

Channel of distribution



Dealers : In Zambia there are over ten dealers engaged in the import and distribution of agricultural imports. Very few of them are specialized firms.

The main dealers are :

Power Equipment	- Messey Ferguson
Duly Motors	- Public owned, privately organized, engaged in both vehicles and agricultural machine for Ford and Yanimar
E.W. Tarry	- Public owned, privately organized, engaged in both vehicle and agricultural equipment import and distribution for Kabuta tractors
Trans-Continental	- Specialized in agricultural equipment for CASE International
Lay Land DAF	- Primarily dealing with trucks but also handling Marshall tractors
Turning & Metals	- A mechanical workshop, also dealing in Renault tractors.

Others include AMIRAN Ltd., Mazembe Tractors Ltd., Industrial Distributors, TATA Zambia Ltd.

Parastatals : There is one big organization (AFE Ltd. representing John Deere) specifically established for the import and distribution of agricultural equipment. Other parastatals with broad line of products also deal with the supply of limited agricultural equipment.

Zambian Cooperative Unions Zambian Cooperative Unions, composed of Zambian Cooperative Federation Ltd. (ZCF), Provencial Cooperative Unions (PCU) and Primary Marketing Unions form a net-work of distribution of primarily farm tools and implements. These unions have taken over the functions of marketing services. ZCF operates as the central purchasing and import agent while the Provencial Unions operate regional distribution centers selling to the primary unions who buy on behalf of farmers.

3. AGRICULTURAL EQUIPMENT MAINTENANCE

3.1 Maintenance organizations

Maintenance of agricultural equipment in Zambia is carried out through different organizations. They consist of dealers, commercial farmers with own workshops, tractor hire service organizations, specialized private service workshops and village black-smiths.

Village black-smiths provide repair services for farm implements in the rural areas. Their number is limited but several technical assistance packages are deployed to promote more black-smith workshops. Among these is the FAO executed project which is presently in its second phase. The aim of the project is to assist small-scale and emergent farmers through the provision of affordable and continuing village black-smith and tractor hire services.

Private service organizations : Such organizations specifically catering for agricultural equipment are few in number and exist in the major industrial towns only, however, there are several general mechanical workshops providing specialialized maintenance services for agricultural equipment.

Tractor hire service organizations: There are three groups of such organizations. The first, a parastatal organization(the Land Development Services under the Ministry of Agriculture and Water Development),operates tractor hire services and land development work on hire scheme. It handles its own maintenance for its fleet; and has a central workshop near Lusaka and branch service facilities in all provinces. The central workshop is an old facility and inadequately equipped and manned to meet maintenance needs of even its own fleet. The branch offices, though reasonably manned, are said not to have the basic facilities to provide reasonable maintenance services. The Land Development Services relies on dealers workshops for major maintenance work.

The second, private tractor hire organizations, provide maintenance servic to their fleet but rely on dealer workshop for serious maintenance work. These hire organizations are practically subsidiaries of commercial farms, or agricultural equipment dealers.

The third, institutional supported hire schemes,such as the FAO executed, project, are said to perform well. Technical assistance packages provided include development maintenance capabilities within the primary cooperativ unions.

Commercial farms maintenance: Most big commercial farms operate their own maintenance facilities.They rely partly on dealers' workshops for heavy maintenance works and supply of spare parts. Due to the current shortage of parts, however, they themselves tend to import and stock spare parts. The quality and level of maintenance work varies from farm to farm. Generally, their facilities play the most important role in the provision of maintenance services.

Dealers workshop : Nearly all major agricultural equipment importers and distributors have some form of maintenance services. The nature of facilities, the built-in capabilities and methods of delivery of services vary from dealer to dealer. Most dealers have nominal facilities. Some such dealers tend to emphasize services for vehicles. This is, in part, due to reduced import of agricultural equipment. Power equipment, AFE, Trans-continental and F.M. Tarry are among the better organized in this group.

Power Equipment has branch service workshop at Kitwe in the copper belt area and a dealer service shop in Mukushi which operates two mobile field service teams. In addition to routine breakdown maintenance, it undertakes REHAB (a monitored repair programme to replace essential parts and put back the tractor to a working condition) and an ROC programme (a rebuilding and upgrading maintenance to bring a tractor to high quality matching that of a new one and warranty equivalent to that given to a new tractor).

AFE: This is a parastatal with well equipped central facilities in Lusaka and branch service workshops at Katare,Chipata and Choma. It also provides mobile field services. Its central workshop has also a well organized unit for the maintenance of irrigation equipment as well as stocked parts store.

The other dealers have workshops in Lusaka as well as operate mobile field service units. The strength of maintenance services is low and, due to inadequacy of equipment, their services are not likely to improve.

3.2 Maintenance practices in use

The dichotomy prevailing in both the type of users of agricultural equipment and in the delivery of maintenance services has resulted in lack of well defined maintenance policies and practices. The practices in use depend on the particular owner of the equipment in question and his awareness of the consequences of the practices he follows.

Planned maintenance is normally practiced by bigger commercial farmers. This is said to have resulted in higher serviceability of equipment. Attempts by some of the dealers to operate regular mobile services by visiting individual farmers once a month is being furstrated by lack of suitable vehicles. As a result it is not consistently practiced.

Dealers maintenance service is mostly provided on request. It is, therefore, not possible to establish maintenance needs and programmes of equipment in use. It follows that specific maintenance levels and periods are not possible to define.

3.3 Major areas of constraints to maintenance

The absence of sound maintenance practices in Zambia is partly due to the absence of national policies and guidelines on maintenance practices. However, even if policy guidelines were formulated, enforcement could be a major constraint due to the diversity of the system of ownership and management.

The high number of makes and models of equipment is the main cause for many of the maintenance associated problems. The need to standardize has been well recognized. There is, however, no indication for its implementation. Its implementation is complicated by the absence of criteria that can be used to select appropriate equipment and existance of doner and credit financed purchases which restrict sources of supply. Further, the inability to manage satisfactorily testing centers and enforce concret mechanization policies are some short falls hindering the implementation of standardization.

The problems associated with too many makes and models include shortages of spare parts and lack of technicians familiar with so many makes and models. Stock for all makes and models have to be maintained. This requires efficient stock management and ties up huge capital, both of which are scarce inputs. These coupled with the absence of planned maintenance practices, the long lead time for the acquisition of foreign exchange and lack of mechanisms for urgent delivery of needed spare parts have further aggravated the availability of spares. Shortage of spares is unanimously considered by users as the most crucial constraint. In regard to problems associated with manpower, this is likely to persist in future as there are no institutions trailor-made to train the personnel of maintenance organizations. Current training is limited to short-term on the-job- training given by some of the dealers of agricultural equipment.

ANNEX V

MAINTENANCE OF AGRICULTURAL EQUIPMENT
CASE STUDY

ZAMBIA

1. BACKGROUND

1.1 Agriculture in Zambia

Zambia's economy has been and still is dominated by the mining sector. However, present trends indicate an intent and positive commitment towards diversification. Accordingly, the importance of agriculture has been increasing consistently though not at the anticipated rate. This is clearly manifested by the percentage contribution of the agricultural sector towards the gross domestic product (GDP).

Gross domestic product at constant 1977 Prices (US$ millions)

	1984	1985	1986
Total GDP	2013	2014	2052
Agriculture	332	344	364
% Agriculture	16.5	17.0	17.7

Source: Interim National Development Plan.

Of the estimated 7.1 million inhabitants (1987 - FAO), close to 70 per cent of the economically active population makes its livelyhood in agriculture. Of the total area of 75.2 million hectars, about 32 million hectars are considered arable. Only about 1.5 million hectars of the latter are estimated to be cultivated (1.16 million hectars in 1986).

The climate is sub-tropical due to the high altitude which varies from 325 meters in the south to 2,000 meters in the north. Most of the agricultural land lies at an altitude of approximately 1,200 meters. Rainfall patterns vary from a minimum of 700 mm in the south to 1,500 mm in the north. Underground water is readily exploitable for agriculture.

The major crops grown consist of maize, cotton, groundnuts, cassava, sorghum, wheat, soya beans, rice, sunflower and tobacco. Of these, maize forms the main crop accounting for 67 per cent of the cultivated land.

Farming in Zambia is carried out by four major groups of farmers, namely :

Commercial farmers: These consist of farmers cultivating over twenty hactars, using intensive farm equipment.

Emergent farmers : These consist of indigenous farmers who are engaged in commercial farming, cultivating five to twenty hectars and using improved farm implements, such as animal traction and hired tractor service.

Peasant farmers: These form the main group of farmers mostly engaged in subsistance farming, cultivating one to five hectars using primarily hand tools and, to a limited extent animal traction.

Institutional farmers : These consist of farmers enjoying institutional support and engaged in commercial and subsistance farming. They are members of cooperatives settlement schemes and the like employing mixed technological inputs.

The relative importance of these four groups can be observed from the table below.

Farming group	Number	Per cent	Estimated Crop area (ha)	Per cent
Commercial farmers	2,708	0.6	220,310	18.9
Emergent farmers	38,429	8.7	202,637	17.3
Peasant farmers	395,021	89.7	714,147	61.1
Institutional farmers	3,332	1.0	30,950	2.7
Total	440,490	100.0	1,168,044	100.0

Source: Planning Division, MAWD 1985/86 Crop Forecasting Survey, Zambia.

According to the Table, commercial farmers, though representing only 0.6 per cent of total farmers, utilize nearly 19 per cent of the cultivated land and contribute nearly 40 per cent to agricultural output.

1.2 Agricultural mechanization in Zambia

In Zambia, all three levels of agricultural mechanization exist, the most predominent level in terms of hectrage coverage (68 per cent of cultivated land) being hand tool technology. Powered equipment are predominant with emergent farmers. Commercial farmers use medium to big horse-power tractors for tillage and combines for harvesting. The implements in use for tillage consist of chisel plough, off-set disc harrows and tine cultivators. Recent trends indicate a tendency to employ minimum tillage practice, such as direct drills.

ANNEX VI

Maintenance of agricultural equipment in Ethiopia

Short Profile

I. BACKGROUND

1.1 Agriculture in Ethiopia

Ethiopia is primarily an agricultural country with over 85 per cent of the population living in rural area and about 78 per cent of the economically active population in agriculture. Agriculture represents 48.3 per cent of GDP (1984) and 90 per cent of foreign exchange earnings.

Ethiopia has a total land area of 124.8 million hectars about 65 per cent is estimated to be potentially suitable for agricultural development. 14.7 per cent is estimated to be currently used for agricultural production. In 1981 only about 7.071 million hectars were estimated to have been under crop.

The country is endowed with diverse climatic conditions suitable for different types of agricultural development. It has several rivers and potential irrigable land of 2.25 million hectars. The altitude varies from 120 meters below sea level to 4,620 meters above sea level and rainfall from 400 mm to 2,000 mm.

A wide variety of crops are grown in Ethiopia including cereals (maize, wheat, sorghum, etc.), pulses (beans, peas, etc.) and oil seeds (rapeseed, sun-flower, noug, etc.). Coffee, cotton and sugar-cane are the main cash crops. Also a wide variety of fruits and vegetables are grown at different climatic zones.

Farming is undertaken primarily by the following four groups:

The peasant : The peasant represents the largest single farmers group both in number and area coverage. In the majority of cases he/she uses animal traction. He/she uses hand tools in areas where animal diseases are prevalent.

Producer cooperatives : These consist of peasant who are organized under the umbrella of cooperatives, jointly own the means of production and farm together. They comprise the second important group of farmers. In most cases they use semi-mechanized farming system in that they utilize powered equipment for critical operations either through hire schemes or ownership of equipment. The level of mechanization varies from cooperative to cooperative.

Settlements : These consist of peasant families who are re-settled in new areas following persistant drought in their own areas. They have been settled in the new areas with significant assistance from the Government. They use semi-mechanized farming system whereby land is ploughed using powered equipment provided by the Government rental organization.

State farms : These are Government commercial farms growing both food and cash crops on a large-scale and using mostly mechanized farming system. They represent the third largest group of farm units, following the peasants and producer co-operatives.

The table below shows the relative importance of each group :

	Area (hectares) 1984	%	Area (hactares) 1988	%
State farms	190,100	3.1	222,000	3.1
Peasant	5,797,100	95.2	6,298,900	89.3
Co-operatives	169,500	2.7	537,000	7.6
Total	6,156,700	100.0	7,057,900	100.0

Source : ONCCP - Review of Agriculture Sector 1980.

1.2 Agricultural mechanization in Ethiopia

In Ethiopia, all three levels of agricultural mechanization exist,the most predominent level being animal drawn technology. Animal traction has been in use in Ethiopia for thousands of years and is widely accepted except where animal diseases have made it uneconomical. The levels of mechanization adopted have, overtime,undergone changes. Brief descriptions of the levels in use are presented below.

Powered equipment :Powered equipment was widely used by commercial farmers and agro-industrial projects prior to the Ethiopian Revolution Following the Ethiopian Revolution which put nationalized farms under state control and the disappearance of the smallest farms, use of powered equipment was confined to the state sector. Prior to takeover with the exception of very large commercial farms use of modern technology and tractorization was limited to critical operations, such as land preparation. With the organization of the peasants into co-operatives, parcellization of land was avoided and a policy of introducing powered equipment to co-operative farms was adopted. Presently, a good number of producers co-operatives use powered machines for critical operations.

Animal traction : As earlier noted, naimal traction is the main source of power for farming activities. A traditional plough (known as maresha) is used for nearly all land preparation work. Several attempts to improve the maresha or replace it with mould-board plough were made but none have been successful. Animal traction still is and will remain to be the most important technology in use in Ethiopia for some time to come.

Hand tools or the hoe culture : Hand tool technology is practiced only in limited areas, specially in the lowlands where animal power is uneconomical. Hand tools are also used for cultivation work where partial mechanization or animal-power is adopted.

2. AGRICULTURAL EQUIPMENT IN ETHIOPIA

2.1 Policy and strategy

Prior to the Ethiopian revolution, policy consideration to regulate the levels of technology to be used in agriculture were not considered. There was, however, a clear commitment to improve the farm implements used by the peasant. Several research and development were carried out and prototypes introduced. Agricultural equipment used by commercial farms were being deployed following the desires and knowledge of individual entrepreneurs and the institutional strength of the marketing organizations.The question of agricultural equipment policy started to be addressed following the restructuring of the agricultural sector under two major categories, i.e. the peasant and state sector. Although there are to-date no explicit policy guidelines, the following major directions have been indicated :

- The state sector is to be developed on the basis of a fully mechanized technology. To this end, over 4,000 tractors and associated equipment were imported into the country since the revolution. A specialized parastatal organization to handle the import and technical support for these equipment has been established.

- The peasant sector is to be re-organized into producers co-operatives which shall adopt partial mechanization through tractor hire service to be organized under the Ministry of Agriculture. To this end, a parastatal mechanization unit has been established and presently operates over 1,244 tractors with their associated equipment and accessories.

The most significant of the policy statements in which the governmemt has made a clear indication of the line of development of agricultural equipment is the one expressed in "The Policy Guidelines for Farmers Producers Co-operatives" issued by the Provisional Military Government of Socialist Ethiopia dated June 1979. The following is stated in Article 5 on page 8 of the guidelines : "It is unrealistic to expect substantial growth in Agricultural development in the absence of improved and modern agricultural machineries. To base ones strategy on the gradual development of the use of improved agricultural machineries such as the gradual step by step change from shovels to hoes, from hoes to improved animal draught implements and then to small tractors, etc... besides restraining man's capabilities it is conservative thinking. In a country like Ethiopia which is running a revolution as long as it is capable to mobilize its human resources, strengthen its mass organizations and raise the political consciousness of its people Ethiopia has neither the time or comfort to follow such a step by step development strategy. All menas and promotional efforts shall have to be found to ensure the availability and expanded utilization of tractors, mowers, threshers, water pumps and irrigation equipments etc.... Among the actions to be taken is to establish at appropriate locations Tractor and Machinery Services Stations." With respect to the small holder, the policy is to equip the peasant with improved implements and introduce new cultivation techniques. To this end, an agricultural implements research and development center has been established and is currently undertaking serious research activities.

2.2 Agricultural equipment used in Ethiopia

Powered equipment

a) Tractors: The types, makes and population of tractors used have undergone several changes. Prior to the revolution the number of makes and models of tractors was quite high and nearly all major makes were represented. Since the revolution, there have been significant imports of tractors for the state sector but only of very few makes and models. FAO's estimate of tractor population is 3,900 while from figures collected from the state farms and the Agricultural Mechanization Services Corporation the total for these two alone exceeds 3,770 tractors. Taking into account tractors owned and operated by producers co-operatives, service co-operatives and relief and rehabilitation centers, a reasonable estimate of total tractor population is about 5,000. The major makes of tractors are ZT tractors from GDP, IMT tractors from Yugoslavia, Massey Ferguson Fiat, and NATFA tractors (locally assembled Baylarus tractor from USSR). There is a small number of other tractors that were imported through bi-lateral arrangements. Tractors in Ethiopia are, primarily, of the medium range, i.e. 70-90 HP, though there is a current trend to use tractors of higher range, 130-150 HP, in the state sector. Their number is, however, limited few. A few 35-50 HP tractors are in use in horticultural farms. It is estimated that less than 50 per cent of the tractor population is operational at present.

b) Harvesting machine : Combined harvesting machines for maize and wheat are owned and operated by the state sector and hire scheme organizations. The number of makes of harvesters are few, comprising mainly those from GDR, Yugoslavia and USSR. The total population of combined harvesters estimated by FAO is 150 units. However, figures received from the state farms and the mechanization corporation give a total of 585 combines. The latter is likely to be close to the true figure as not many are expected to be owned outside these two organizations. Serviceability is slightly higher for combines as a good number of them are new acquisitions. Treshers and corn shellers are als imported and distributed to the peasants but their numbers are insignificant.

c) Agricultural implements : Agricultural implements in use in association with powered machines consist of :

- Sub-soilers (not extensively used);
- Disc-ploughs (4-5 farrows);
- Mould-board ploughs (4-5 farrows);
- Disc harrows;
- Cultivators and ridgers; and
- Planters and seed drills.

Other auxilliary equipment used include : sprayers, spreaders, levelers and trailors.

Disc ploughs and mould-board ploughs are extensively used. Minimum tillag practice is yet to be introduced.

Table 2.1 below shows the total agricultural equipment currently in use by the state farms and tractor hire organizations.

Table 2.1

Type of equipment	State farms	Agricultural Mechanization Corporation	Total
Tractors	2,526	1,244	3,770
Ploughs (disc and mould board)	1,014	1,288	2,302
Harrows	683	924	1,607
Ridgers	128	3	131
Levelers	64	-	64
Planters and seed drills	306	8	314
Seed and fertilizer spreaders	377	14	391
Sprayers	146	-	146
Cultivators	382	24	406
Trailors	960	366	1,326
Combine harvesters	442	143	585

d) Irrigation equipment : Most irrigated farms are based on gravity system and only a few of them use high discharge pumps to pump water from the rivers. As a result, the population of irrigation equipment, particularly the more complex ones, is rather small.

e) Animal traction : In Ethiopia, the primary implement in use with animal power is the traditional[1/] 'Maresha' which consists of a steel shear, and it is attached to a frame comprising two wooden wings, a handle, a beam, a neck yoke and a harness. The wooden parts of the Maresha are fitted by the farmer while the plough shear is made by the local black-smith. It is estimated that each peasant farmer has at least one Maresha plough and on the basis of the present peasant population of about 5.8 million, the total number of mareshas is expected to exceed this figure. Attempts to introduce other animal drawn implements have not been successful.

Demand, supply and distribution of agricultural equipment

Demand

Demand for agricultural equipment shows different patterns compared to other African countries. As Ethiopia follows planned economy, the level of consumption of agricultural equipment depends upon the **level** of implementation of planned targets. This applies to demand for powered machine which depends on the planned expansion of the state sector and the ability to organize peasants into co-operatives.

According to the ten year indicative plan, by 1994 state farms are to cultivate about 500,000 hectares and producers cooperatives close to 4.4 million hectars together representing 53 per cent of the total planned cultivated area. In view of the low rate of plan implementation by state farms and producers co-operatives, it appears that demand for powered equipment is not likely to grow. HMT in its Model Pre-feasibility Report for Agricultural Machinery, Equipment and Tractor, April 1988, prepared for ECA put annual demand at 1,580 tractors during 1991-1992 tractors with 50-100 HP constituting the major group.

Demand for implements to be used along with tractors are expected to increase proportional to the number of tractors while demand for animal drawn implements, the 'Maresha', is to decrease. In regard to improved animal drawn farm implements it is not likely that they will be developed and successfully introduced in the foreseeable future. Demand for threshers and shellers are expected to grow with the establishment of rural technology centers.

Supply

The supply of agricultural equipment depends on the type of equipment used. It can be generalized that nearly all powered equipment and their associated accessories are met through imports and animal drawn implements through local manufacture. A local assembly plant (Nazareth Tractor Assembly Plant) supplies tractors imported from the USSR on PKD basis. It has a capacity to assemble 1000 units in a year in a single shift and can produce up to 3,000 in three shifts. It assembles only one size of tractor (80-82 HP) in both two-wheel and four-wheel drive versions. Tractor needs of other sizes are met through imports.

In regard to animal drawn farm implements and tools, several establishments, both in the formal and informal sectors, supply the needs. The establishments engaged in the manufacture of animal drawn implements and hand tools consist of :

- Ethiopian Metal Tools Factory - a parastatal company;
- Edge-Bessera; Maresha, Wegele and Belawa Producer Cooperative - a producer co-operative;
- Rural Technology Centers of the Ministry of Agriculture (seven centers);
- Handicraft Cooperatives; and
- Artisans.

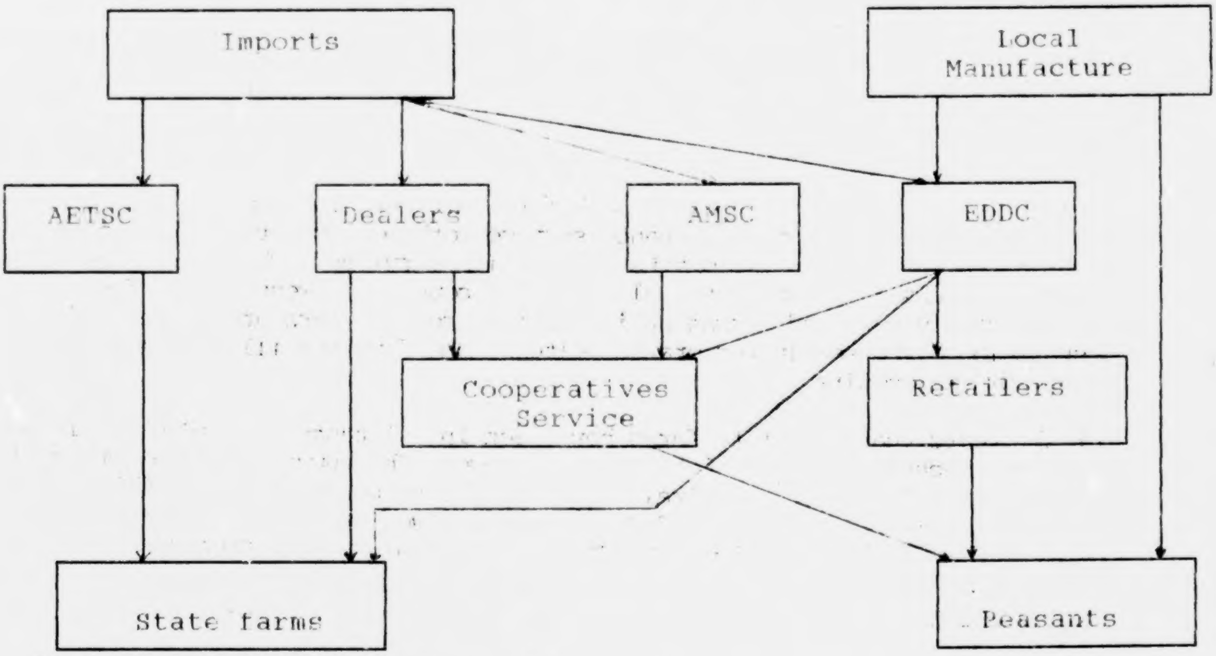
The production of these establishments consists of maresha plough, cultivator (spike - tooth harrow), threshers, hoes, gessos (digging hoes), axes and the like.

Distribution

The channels of distribution for agricultural equipment depend on the users. State farms get their agricultural equipment through the Agricultural Equipment and Technical Services Corporation (AETSC) a parastatal organized specifically established for this purpose.

All imports of agricultural equipment, including the PKD's for the local tractor assembling plant are made and distributed by this organization. Locally manufactured tools are procurred direct by the State Farm Corporation. The other channel. Agricultural Mechanization Service Corporation (AMSC), serves the peasant sector. It was organized recently and is entrusted with the responsibility to procure and distribute agricultural equipment to the peasants. This is the same organization giving tractor hire services. Farm tools and small implements are procurred by Peasant Service Co-operatives and distributed to individual peasant or, in some cases, procurred directly by peasants from the retail market or local artisan. A few agricultural equipment dealers still operate in the country and import tractors and farm implements on behalf of end users. Locally manufactured tools and implements are marketed through Ethiopian Domestic Distribution Corporation (EDDC).

The channel of destibutions described above is shown in the chart below.



3. AGRICULTURAL EQUIPMENT MAINTENANCE

3.1 Maintenance Organizations

There are three primary organizations catering for maintenance services for agricultural equipment: those geared to serve state farms, the state tractor hire service organization catering for its own needs and peasant cooperatives and dealers. A brief discription of the maintenance net-work which is well structured is described below.

State farm facilities

Maintenance service is provided to state farms by either the maintenance organization of the Agricultural Equipment and Technical Services Corporation (AETSC) or maintenance workshops organized within the state farm corporations.

AETSC imports agricultural equipment and operates a central maintenance organization for pre-sales services, major repairs and overhaul of agricultural equipment as well as mobile service units. It has one modern central workshop built on the assembly line principle for total rebuilding of agricultural equipment and their components. The facilities of the workshop include a well equipped mechanical unit for regeneration of parts and components. It has a rebuilding capacity of 500 units of engines per annum and a good number of trained engineers and technicians, supported by manufacturers engineers.

AETSC is in the process of constructing regional workshops in three zones, each capable of total overhauling of 500 tractors per annum. The first unit in the western part of the country is nearing completion. The other two units to be built are in the south and south-eastern part of the country. These with the planned regional workshops to be implemented by the Agricultural Mechanization Services Corporation in the northern and north-eastern part of the country, would eventually give the country the capability and capacity to undertake major repair works.

Within the State Farm Corporation, each farm unit covering about 6,000 hectars owns and operates a light maintenance service workshop for preventive maintenance, replacement of parts and compontnts and routine services. There are a total of 46 service workshops distributed all over the country. Twenty four of these have adequately equipped permanent infrastructures. Others are either under construction or housed in temporary shelters, and five are illequipped, lacking the capability required.

Over the years that the state farms have been in existance, a gradual build-up of trained technical personnel has been achieved. The number of such personnel is given in Table 3.1 below. Training continues to be provided by AETSC which operates a training center in Addis Ababa. It gives orientation, skill upgrading and refreshment courses on agricultural equipment maintenance.

State hire service facilities

The State Agricultural Mechanization Services Corporation is under the overall supervision of the Ministry of Agriculture. It was established to perform the following three basic objectives :

- Produce and distribute agricultural equipment to the peasant sector;
- Provide machinery hire services to the peasant sector; and
- Deliver maintenance service for agricultural equipment to the peasant sector.

Table 3.1 Number of technical personnel within the State Farms

Skills	Foreman	Senior	Technician	Junior	Helper	Total
Management	10					10
Mechanic	12	44	538	787	86	1,467
Electrician	1	6	282	245	25	559
Welder	1	6	90	107	16	220
Machinist	1	4	28	2		35
Agro-mechanic		49	42	52		143
Total	25	109	980	1,193	127	2,434

In order to fulfill the above objectives, it is in the process of building-up the necessary infrastructure. Being newly established (only four years old), it is still a long way from being a maintenance force. It is structured in the following hierarchy : a main station covering approximately 30,000 - 50,000 hectars, a brigade covering 6,000-10,000 hectars and a mobile work unit covering 2,000-3,000 hecthrs

The above structure will have a regional workshop at the main station, a service workshop (equivalent to farm workshop) at brigade level and a mobile service unit at each work unit. At present, there are call for six main stations and 18 brigades. Pending the implementation of the complete infrastructure, it has developed temporary facilities at each of the brigade locations and operates mobile teams from its headquarters in Addis Ababa. The composition of manpower is given in Table 3.2.

Table 3.2 Number of Technicans with Agricultural Mechanization Service Corporation

Skills	Foreman	Senior	Technician	Junior	Helper	Total
Management	7					7
Mechanic	12	5	82	31	30	160
Electrician		2	17	18	2	39
Welder		1	9	12	2	24
Tyre repairer			18		12	30
Agro-mechanic			2			2
Total	19	8	128	61	46	262

Source : AMSC.

Dealers facilities: At present, there is only one dealer, Ries-Engineeri the Massey Furgison Agent which still has a well organized workshop ar continues to deliver maintenance services on agricultural equipment. Others such as John Deere, Ford and Fiat dealers, who had well establish workshops have either closed down or are operating at a very low capacit utilization due to low import of agricultural equipment.

Black-smiths facilities : Black-smiths (individuals and cooperatives) ar found all over the country and provide maintenance services on farm implements of the peasant sector. However, their services are limite to repair by forging and grinding operations only. They lack basic facilities to undertake higher maintenance functions. Rural technology centers and adult education centers organized under the Ministry of Agriculture assist and train farmers in maintenance and supplement the services provided by the black-smiths.

3.2 Maintenance practices in use

Though agricultural equipment ownership and operation is well defined, the implementation of a defined maintenance practices is not clear. This partly could be due to the emphasis given to production and not so much to maintenance. In regard to the state farms, the necessary infrastruct has already been developed while the development of a maintenance plan is currently under consideration. In respect of machinery hire scheme, attempts are being made to follow preventive maintenance practices, whic due to lack of infrastructure and dispersed locations of costomers, is not fully effective. From these it is apparent that there is a need to develop systematic maintenance practices.

3.3 Major constraints to maintenance

The main constraints to the delivery of satisfactory maintenance service in Ethiopia are those experienced by developing countries. These includ shortages of spare parts due to scarcity of foreign exchange; scarcity of experienced, skilled technicians; and management systems that leave much to be desired. Though some basic infrastructures have been developed and there is a Government policy to improve maintenance capability, it should be noted that the building of infrastructures and training of skilled technicians takes time.

The ability of the country to identify, select and purchase the most appropriate equipment is another maintenance problem. The mechanism or the institutional frame-work for such a task has not been fully developed yet. It should be noted, however, that there exists in the country conditions for limiting the makes and models of and therefore the possibility for standardizing agricultural equipment.

Other significant constrains include lack of incentives and absence of motivating schemes. As a result, labour productivity is low and loss of skilled manpower is high. With the development and implementation of maintenance management systems, the construction of the regional and branch maintenance establishments and effective use of manpower development scheme, constraints to maintenance could be substantially mitigated.